THE RELATIONSHIP BETWEEN SEVERITY OF PHONOLOGICAL DISABILITY AND GENERALIZATION OF LEARNING OF /s/ PLUS STOP CLUSTERS IN YOUNG CHILDREN

By

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This dissertation is lovingly dedicated to
my mother, Ruby Harmon Stewart.

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THE RELATIONSHIP BETWEEN SEVERITY OF PHONOLOGICAL DISABILITY AND GENERALIZATION OF LEARNING OF /s/ PLUS STOP CLUSTERS IN YOUNG CHILDREN

By

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Major Department: Speech

Most clinicians intuitively feel that generalization takes place during remediation. However, empirical study of this notion has not been widespread. The purpose of this investigation was to examine the effect of severity of phonological disorder on the rate of generalization, using a specific training program designed to eliminate one phonological process, cluster reduction. Using a within-subject experimental design, phonological performance of six children with phonological severity ratings of moderate or severe was followed through initial evaluation, baseline, generalization measurement, and follow-up evaluation. The initial evaluation was based on analyses of a phonological assessment instrument, and a baseline word list, as well as a generative phonological analysis of spontaneous speech production. Training was administered to one of the three subjects at each severity level while the other subjects

continued in baseline. Each subject received training on the initial /s/ plus stop clusters, /sp/ and /st/. Progress during training was measured through the use of generalization probes with a training criterion of 90% correct across the two clusters across two sessions. When one subject reached criterion, another subject then began training. Accuracy of production on the untrained /s/ plus stop cluster /sk/ and the control cluster /br/ were followed during training. A one-month follow-up evaluation identical with the initial evaluation was administered to all subjects.

Results indicated that the initial phonological disorder severity rating could serve as a predictor of generalization of training, with subjects in the moderate group making greater progress than their counterparts in the severe group. All subjects showed increases in the percentages of correct cluster production at the follow-up. Subjects with moderate severity ratings made the greatest increases in correct cluster production, including /s/ plus stop clusters. Five of the six subjects exhibited generalization of learning to the untrained cluster, /sk/. Individual differences between-subjects, within-groups were noted. Although not included in the formal analysis of results, phonological performance for one additional subject in the profound range of severity was followed during evaluation, treatment, and follow-up.

CHAPTER 1
INTRODUCTION AND REVIEW OF THE LITERATURE

Introduction

Development of the phonological system starts at birth as the infant begins to learn to discriminate between sounds. This process of development continues through approximately age 7; at this point the child typically has a complete phonetic inventory. Some refinement of this system occurs as the child learns to read, write, and spell, with changes due to new learning in morphology and semantics (Ingram, 1976). The entire developmental process is gradual, and children of the same age may sound quite different based on their speech production. Although there is considerable variability from child to child, there are definitive criteria that can be used to establish the presence of a phonological disability. For those children who have difficulty learning the sound system of language, remediation may be necessary.

Traditional approaches to remediation of misarticulations focused on individual phonemes (Van Riper, 1972). Such treatment programs began with auditory or sensory-perceptual training with discrimination activities being of primary importance (Weiss, Gordon, & Lillywhite, 1980). Children were first taught to produce sounds as isolated

segments with the emphasis on improving motoric output. The treatment process for children with multiple misarticulations often was long and tedious.

In the early 1970's, the field of speech-language pathology was greatly influenced by contributions from the field of linguistics. In the area of articulation disorders, there was a shift in focus from traditional techniques to consideration of the underlying system responsible for the use of sound segments. The assumption that development of speech was systematic and possibly rule-governed led to a new approach in remediation (Blache, 1978; McReynolds & Bennet, 1972; Singh & Polen, 1972). One approach involved the use of distinctive features, based on the grouping of sounds into classes according to common features, such as nasality or voicing. McReynolds and Bennet (1972) developed one of the first distinctive feature remediation approaches. Such approaches generally used one or more target phonemes (e.g., /p/ and /f/) to train a given feature (e.g., the [-/+ continuant] feature) with the ultimate goal of generalization across and within sound classes.

This early work provided the basis for later development of remediation programs in phonology, including phonological process approaches. Emphasis shifted from training isolated phonemes to training entire sound classes. The assumptions of phonological process treatment were that such remediation programs were more efficient and that remediation involved

rule learning (Newman, Creaghead, & Secord, 1985). Thus, there was a shift from phonetic to phonemic techniques with treatment generally beginning at the meaningful word level. Analysis techniques, borrowed from linguists and refined by speech-language pathologists, identified the rule-governed nature of the speech of children with phonological disabilities. Remediation programs were developed to eliminate phonological processes or patterns of error that interfered with the development of adult speech (Fokes, 1982; Hodson & Paden, 1983; Weiner, 1979, 1981). Terms such as phonological process and phonological rule began to be used throughout the field. Concepts of generalization, taken from behavior theory, became an integral part of the remediation process.

At present, many different approaches to remediation of phonological disorders can be found in the literature. However, one assumption common to all approaches is that phonological remediation results in generalization to untrained stimuli. Training to change one sound affected by a process or rule is intended to result in the correction of several other individual phonemes as well (Newman, Creaghead, & Secord, 1985). This notion that a speech sound need not be taught in all positions, in all possible combinations, and in all possible words forms the basis of the work concerning generalization learning. Most clinicians intuitively feel that generalization takes place during phonological

remediation. However, to date, empirical study of the efficacy of phonological remediation or of the extent of generalization in phonological remediation is not widespread.

Thus, the purpose of this investigation is to determine the relationship between severity of phonological disability and generalization learning. The amount of generalization learning for 6 subjects will be measured following phonological remediation to reduce the occurrence of one phonological process, reduction of consonant clusters. Individual learning patterns will be analyzed and described.

Review of the Literature

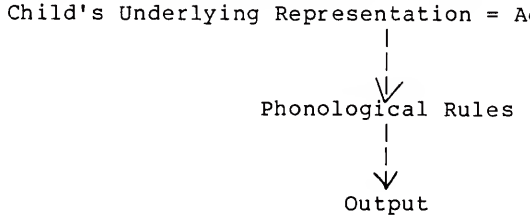
The following review will include an overview of the acquisition of normal and disordered phonology, phonological treatment, and consonant cluster acquisition. A final section will include discussion of generalization learning, including information on facilitation and individual differences.

Phonological Development

Underlying representation. The process of acquisition of the sound system of any language follows a gradual and somewhat orderly pattern with increasing precision in articulation noted as development progresses (Stoel-Gammon & Dunn, 1985). Children develop phonological competence in a gradual manner as their speech production begins to approximate that of the adult model. Thus, it has become increasingly more important to develop a mode of discussion

of this acquisition process, including a model of the underlying representation of children's speech. It is this underlying representation that provides input to phonological rules that may be operating in a child's speech.

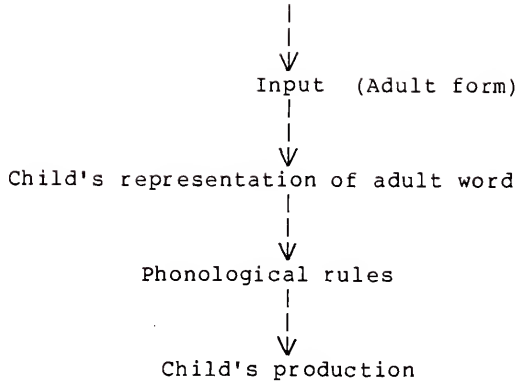
At the present time, there are two major positions that attempt to explain the nature of a child's underlying representation. These two views represent two ends of a continuum. The first position views the child as having an underlying representation of words and sounds that is identical to the adult surface form (Braine, 1974; Donegan & Stampe, 1979; Ingram, 1974, 1976; Menn, 1978; Smith, 1973; Stampe, 1979). A schematic representation of this view can be seen below:



The primary assumption of this point of view is the equivalence of the child's underlying representation and the adult surface form. The child's production is simplified due to the application of phonological rules. These rules are present because of the child's immature articulatory abilities. Smith (1973) suggested that children have normal perceptual skills but that correct production was achieved

only after gradual progression through certain stages, called "realisation rules." Donegan and Stampe (1979) stated that a child's productions are governed by phonetic difficulty and not by a different system of cognitive organization or underlying representation. Macken (1984) suggested that if this position of equal forms for adult and child is to be supported, one must assume that the child has apparently perfect perception and imperfect articulation. However, studies by Broen and Strange (1980) and by Barton (1978) determined that the child's perceptual development of the ambient language is complete by the time the child begins to produce phonemic contrasts. The child's perceptual system differs from the adult system in that the child produces all and only the contrasts perceived, and production is based on the perception of these contrasts. In other words, perception may sometime precede production. Such issues have yet to be resolved. Support for the first view of the child's underlying representations has been made primarily through anecdotal evidence (Macken, 1980).

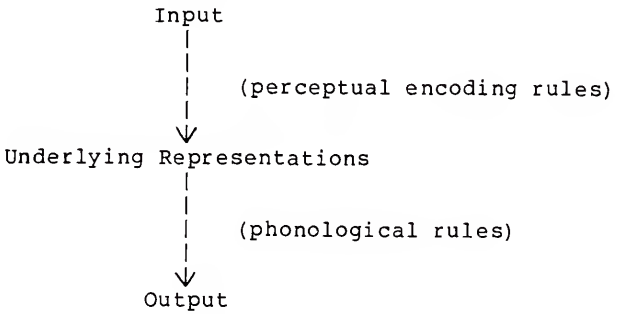
The second view hypothesizes that the child has his own system independent of the ambient adult system (Dinnsen, 1984; Dinnsen & Elbert, 1984; Dinnsen, Elbert & Weismer, 1979: Macken, 1980; Maxwell & Weismer, 1982; Weismer, Dinnsen & Elbert, 1981). The schematic representation of this view is as follows:



Studies based on this view have described three types of misarticulating systems and have attempted to describe the children with these systems. The first type of child has underlying representations similar to the ambient language, but applies a set of phonological rules dissimilar to that of the ambient language. The second type of child has unique underlying representations and phonotactic constraints (i.e., what sounds and sound sequences can occur), very different from the ambient language. Finally, a third type of child could have the same number of distinctions or contrastive phonemes as that of the ambient system; however, the distinctions would not be the same. Empirical evidence must be considered when attempting to validate this second view.

Macken (1980) offered what she referred to as an optimal model for discussing a child's underlying representation. This model takes into account evidence from both views. Macken proposed that the child's phonological

system may contain both correct and incorrect underlying representations that require the application of phonological rules for some words and perceptual encoding rules for other words. This model is depicted below:



In this view, the perceptual encoding rules and the phonological rules may or may not be present in the system of any given child. Two conditions may be noted. A sound may enter the child's underlying representation in a misperceived form, through the application of perceptual encoding rules. The output would then be unlike the adult model without the application of phonological rules. Conversely, if there is evidence of a correct underlying representation but the output differs from that of the ambient language, then perceptual encoding rules would not be evident; unique phonological (output) rules could be identified.

Ingram (1976) proposed that the developing child is actively perceiving, organizing, and producing speech. Simplifications can occur on any of these three levels. The

child may simplify the inventory of sounds and syllables in adult words (perception), simplify the use of contrastive sounds and syllables (organization), or simplify the motoric demands of sounds and syllables (production). Ingram suggested that a child's speech organization could be placed on a continuum from the simplest model to the more complex. It may not always be necessary to consider the intervening or underlying level of a child's system but instead simply determine the child's set of rules based on output. Such analysis is typical of the more traditional methods of evaluation. However, Ingram cautions that such a procedure results in only a partial description of the child's actual system.

Edwards and Shriberg (1983) summarized the sound system of language in terms of covert and overt knowledge (Figure 1). The phonological system has as its primary task the translation of input messages into overt speech production. The covert or underlying level of this phonological system is made up of four types of knowledge: 1) knowledge about which sounds are meaningful in the language, 2) knowledge about ways in which these sounds can be sequenced in morphemes and words, 3) knowledge of the rules for alteration of sounds due to morphological changes, and 4) knowledge of the rules that dictate the appropriate allophonic variants of phonemes. In proposing this model, Edwards and Shriberg made no claims regarding the status of

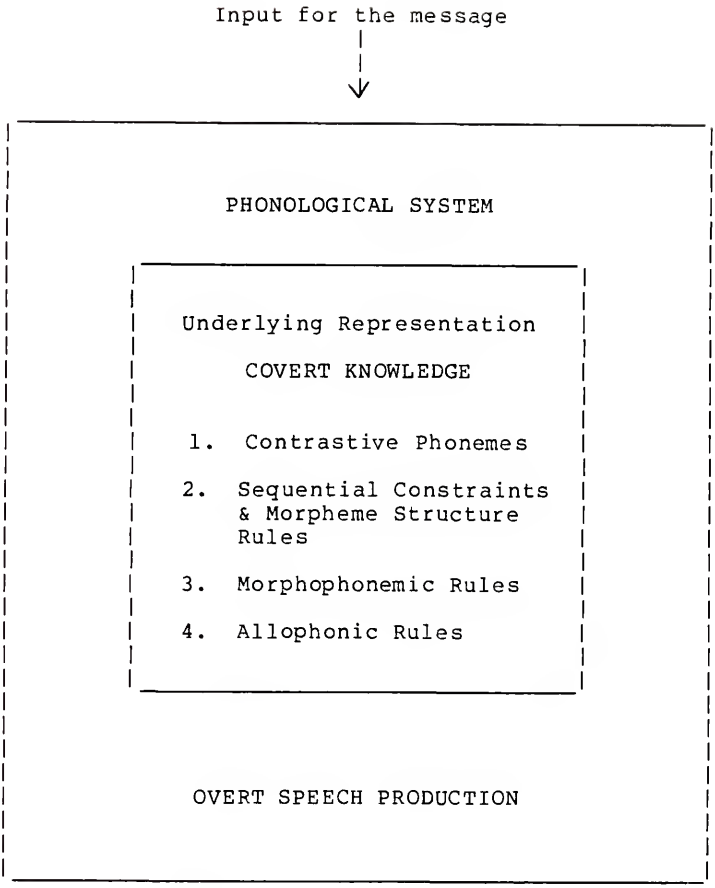


Figure 1. An illustration of the two levels of phonology, the covert and overt levels of speech.

a child's underlying representation, i.e., whether it is the same as or different from the adult surface form. Instead, they attempted to outline the components present in any underlying representation, adult or child. To determine the underlying representation, the phonologist must primarily rely on overt speech production to determine the proposed status of this covert component.

Phonological process. During earliest development, from birth to 10 months, the infant develops the imitative ability and communicates through gestures and crying. Essential prerequisites for later phonological acquisition develop during this early stage. The infant develops rapid perceptual discrimination and begins babbling or sound play. This babbling will later merge into the child's first words. An equally important development is the child's ever-increasing ability to imitate the sounds and gestures of others (Ingram, 1976).

Between the ages of 1:0 (years:months) and 1:6, the child begins using one-word utterances, with the development of approximately a 50-word vocabulary by age 1:6. Ferguson and Farwell (1975) emphasized the role of the single word in this stage of acquisition. The child is actively acquiring a set of lexical items as well as a phonological system. Ferguson and Farwell suggested that acquisition of this system may be greatly influenced by the particular words a child produces. Early acquisition is characterized by

variation in production, selectivity in word choice, and regression of word forms, i.e., early productions may be more accurate than later occurring productions. That the child initially produces an entire word unit, basically unaware of the individual phonemes, was suggested by Ferguson and Farwell as one possible explanation for regression. Change in production occurs as the child constructs an individual phonological system and a gradual awareness evolves. As the development of two-word utterances begins, the child demonstrates a very active development of the phonological system. At this time the child develops a rapidly increasing vocabulary. As this spoken vocabulary size increases, the child is faced with the first real need to develop an orderly phonological system (Ingram, 1976). The use of phonological simplification processes then becomes the primary vehicle of organization for the developing child.

In normally developing children, the greatest use of the phonological simplification processes first described by Stampe (1973) occurs during the most active speech acquisition period between 2 and 4 years of age (Dyson, 1985; Dyson & Paden, 1983). "A phonological process is a descriptive rule or statement which accounts for errors of substitution, omission, or deletion" (Elbert & Gierut, 1986, p. 26). Edwards and Shriberg (1983) defined a phonological process as any systematic change that affects a sound sequence or sound class. Most definitions of phonological

process assume that a basic form called an underlying or phonological representation is present or stored in the child's system and may be changed prior to output through application of the phonological process. The resulting form is considered the surface form or the phonetic representation. As previously stated, the underlying representation is also referred to as covert knowledge, and the surface form is called overt knowledge.

Ingram (1976) suggested that phonological processes fall into three major categories: syllable structure processes, assimilation processes, and substitution processes. Syllable structure processes are those that result in a simplified syllable or word shape. For example, in a word such as cat, the final /t/ may be deleted, resulting in the open-syllable [kæ]. Assimilatory processes are found when one phoneme is overly influenced by another phoneme in the word, e.g., truck is produced as [krʌk]. The substitution processes are those that generally affect an entire class of sounds, often involving substitution of one class for another. Common examples include the fronting of velars to alveolars (e.g., /k/ ---> /t/) and the gliding of liquids (e.g., /l/ ---> /w/) (Stoel-Gammon & Dunn, 1985).

Stoel-Gammon and Dunn (1985) summarized the results of several longitudinal and cross-sectional studies of normally-developing children. Several processes, including unstressed syllable deletion, final consonant deletion, gliding, and

cluster reduction, are present in the speech of most children. However, two major divisions were established based on occurrence of the phonological processes, those that disappear by age 3 and those that persist beyond age 3. Those that are normally eliminated by age 3 are presented below.

1. Unstressed syllable deletion refers to the deletion of the least stressed syllable or syllables in a word, e.g., potato ---> [tēɪto].
2. Deletion of final consonants occurs when the postvocalic consonant or consonant cluster is deleted, e.g., cat ---> [kæ].
3. Doubling refers to the repetition of a target word, usually a one-syllable word, resulting in the creation of a multisyllabic form, e.g., ball ---> [bɑbɑ].
4. Diminutization is described as the addition of /i/ to a target form, e.g., dog ---> [dɑgi].
5. Velar fronting refers to the substitution of an alveolar for a velar sound, e.g., go ---> [dōʊ̄].
6. Consonant assimilation is described as a harmony process, e.g., two sounds become more alike or one sound assumes features from the other sound. Stoel-Gammon and Dunn (1985) listed three common patterns of consonant assimilation: a) Labial assimilation, gum ---> [bʌm]; b) Velar assimilation, tock ---> [kɑk]; and c) Nasal assimilation, time ---> [nāɪm].

7. Reduplication refers to the assimilation of one syllable to another with a resulting duplicated form, e.g., water ---> [wawa].

8. Prevocalic voicing is described as the voicing of a voiceless obstruent in the prevocalic position, e.g., tie ---> [dɑ̄ɪ].

Stoel-Gammon and Dunn (1985) indicated that several processes may persist beyond the age of 3, even in normal children. However, they also stated that the processes listed below may never occur in the speech of some children.

1. Cluster reduction refers to the simplification of a consonant cluster by deleting one or two phonemes, e.g., blue ---> [bu] or squirrel ---> [wɝl].

2. Epenthesis is defined as the insertion of an unstressed vowel, usually in an initial cluster or after a final voiced stop, e.g., blue ---> [bəlu] or big ---> [bɪgə].

3. Gliding refers to the substitution of a glide for a prevocalic liquid, with /w/ usually replacing /r/ and /w/ or /j/ replacing /l/, e.g., red ---> [wɛd] and light ---> [wɑ̄ɪt] or [jɑ̄ɪt].

4. Vocalization or vowelization is defined as the substitution of a non-/r/-colored vowel for a postvocalic or syllabic liquid, e.g., zipper ---> [zɪpə] or table ---> [tēɪbu].

5. Stopping occurs when a fricative or affricate is replaced by a stop or when a fricative is replaced by an affricate, e.g., sun ---> [tʌn].
6. Depalatization refers to the substitution of an alveolar fricative or affricate for a palatal fricative or affricate, e.g., fish ---> [fɪs].
7. Final devoicing refers to the devoicing of a word-final obstruent, e.g., dog ---> [dɑk].

By age 4, the child should have reasonable control over the phonemes of English and by age 5, should match the ambient language fairly closely (Compton, 1975). The child should now be trying to master those sounds of English that are motorically difficult, e.g., /r/ and /l/, and those words that are linguistically complex, e.g., multisyllabic words.

The period from age 4 to age 6 or 7 is marked by an increase in the number of complex sentence structures. The normally developing child will have completed the phonetic inventory by this time and will have all the sounds of English in the spoken repertoire. Any further changes in the phonological system will usually be the result of training in reading, writing, and spelling. The child's speech patterns are fairly well fixed by this point in development (Ingram, 1976).

Disordered phonological development

Descriptions of children with phonological disorders are usually based on our knowledge of normal children (Compton,

1975; Oller, 1974). In fact, children with phonological disorders often sound like normal children at earlier stages of development (Elbert, 1983; Ingram, 1976; Stoel-Gammon & Dunn, 1985). Disordered phonology results when the child fails to eliminate early simplification patterns. The child may then add new processes or rules to deal with the increasing linguistic complexity and with the increasing demands for more intelligible speech. This child may then be seen as different and not just delayed (Compton, 1975; Ingram, 1976; Stoel-Gammon & Dunn, 1985). Processes may become more complex or possibly ordered. For example, at an early stage, a child may replace alveolar sounds with velars. During later stages, as the child attempts to produce fricatives, they may be replaced by alveolar stops, which are then replaced by velar stops. It may become difficult to determine the ordering of the phonological processes because many of them should have been discarded in the development from stage to stage but were instead altered in some way to accommodate newly developed processes (Compton, 1975).

The study of speech production (overt speech) errors would be simplified if one could make conclusions about the underlying representation (covert speech). As previously discussed, there are two opposing viewpoints regarding the child's internal representation of phonology. The first assumes that the child may have an underlying representation identical to that of the adult model with different

productions resulting from application of various simplification processes (Hodson, 1980; Ingram, 1976, Shriberg & Kwiatkowski, 1980; Stampe, 1979). In the case of phonological disability, it then becomes necessary to assess the child's overt speech production and determine which simplification processes are being used. This determination is typically made by examining a sample of speech, making direct comparisons between the adult and child forms, and categorizing "non-adult" productions using a set of commonly occurring phonological processes. The second view assumes that the child may or may not have the correct, adult underlying representation. Instead, each child's individual underlying representation must be determined prior to developing any assumptions about the system. A method of evaluation of surface forms to determine underlying representations has been developed using the principles of generative phonology (Gierut, 1985; Macken, 1980; Maxwell, 1981). Use of such analysis procedures have shown that a child may have different underlying forms than those of adults. Elbert and Gierut (1986) reported that the use of generative phonological analysis is useful with children with severe phonological disorders because such analysis provides a profile of underlying knowledge about the child's ambient sound system, allowing for development of individually determined remediation targets.

Phonological Remediation

Traditionally, remediation for children with multiple sound errors targeted each error phoneme individually. In most cases, the time spent in remediation was considerable because each sound had to be trained to criterion in isolation, words, sentences, and conversation. Phonologically-based remediation targets an entire sound class or word structure resulting in a more efficient use of a training session. Targeting a word structure, such as final consonant deletion, involves the use of several exemplars with differing characteristics of place and manner, in an effort to facilitate broad generalization of the correct pattern, final consonants. By broadening the training from correction of individual sounds to elimination of processes, the goal of reorganization of the phonological system can be reached more efficiently and effectively (Newman, Creaghead, & Secord, 1985; Weiss, Gordon, & Lillywhite, 1980).

Remediation typically has the primary goal of facilitating the development of the adult phonological system in a child with a phonological disorder. Phonological remediation is based upon the systematic nature of phonology and uses conceptual rather than motoric activities. Specifically, drill or production practice is not the main focus in this type of remediation. Instead, remediation activities demonstrate the principle that sounds are used to

contrast meaning (Stoel-Gammon & Dunn, 1985). Thus, remediation is geared toward treating members of a sound class in terms of how they are used contrastively or how they are combined in different word structures instead of the traditional focus on single phoneme training.

Approaches to phonological remediation are being developed at a rapid pace in the field of speech-language pathology. Various approaches can be found based on differing theortical orientations. It is important to consider the theoretical viewpoint when attempting to fully understand or implement any training program. Phonologists who assume the child has the same underlying form as the adult, approach remediation differently than those who assume the child has a unique system. Assessment and remediation goals or techniques may often appear similar, but the choice of training targets is different based upon the two viewpoints. The former approach remediation from a more traditional point of view with errors or error patterns being the main unit of focus. The latter attempt to determine the child's individual unique rule system and to plan targets based on elimination or alteration of these rules.

Several different views regarding the child's underlying system are represented in the current body of phonological remediation literature; however, one factor appears to be common to all remediation programs. Such programs are designed around the "underlying organizational concept of a

process" (Stoel-Gammon & Dunn, 1985, p. 174). This organizational concept refers to the focus in remediation of changes affecting an entire sound class or word structure rather than individual phonemes. Six general principles of phonological remediation that apply to almost all phonological process remediation programs, have been outlined by Stoel-Gammon and Dunn (1985).

1. Underlying factors such as auditory abilities, cognitive and language skills, and oral motor functioning should be considered because they may contribute to etiology.
2. Each child must be viewed as an individual.
3. When planning a remediation program, the clinician must be aware of the normal acquisition data. Effective remediation allows the child to follow a progressive program that parallels gradual normal acquisition.
4. The clinician must use a broad framework of phonology when planning treatment. By keeping the broader aspects in mind, one does not focus on only one aspect of remediation, overlooking or ignoring other equally important aspects.
5. The goal of the remediation program should be to train the child to monitor correct and incorrect responses. The learning of this skill is essential for generalization. Training should occur not only at the perception and production levels, but should also attempt to improve the child's awareness of productions.

6. The clinician must develop an efficient method of systematically measuring progress in the remediation program. This measurement must include detailed analysis prior to the initiation of therapy, periodic analysis of the skill being trained, and probing of generalization of newly learned behaviors.

Cluster Reduction

Of specific interest to this investigation is the process of cluster reduction. This process is often defined as the simplification of a consonant cluster by reducing it to one or two phonemes, (e.g., black ---> [bæk], string ---> [sɪŋ]) (Stoel-Gammon & Dunn, 1985). McReynolds and Elbert (1981a) further extended the definition by including the substitution of one or more sounds in the cluster or the insertion of an epenthetic vowel between the consonants of the cluster, (e.g., flower ---> [pwa͡ʊwɚ], or blue ---> [bəlu]). Examination of cluster reduction typically includes consideration of the stages observed in the normal development of consonant clusters. Whereas the consonant-vowel (CV) syllable shape is the most common type in English and usually is first acquired between the ages of 1:0 and 1:6 (Stoel-Gammon & Dunn, 1985), word-initial consonant clusters (CCV, CCCV) do not emerge until about 2 years of age (Greenlee, 1974). Although consonant clusters emerge early, they are not completely mastered until approximately age 4:0 (Grunwell, 1982; Templin, 1957). The simplification process

of cluster reduction may be used during the early stages in an effort to maintain the most common syllable shape, CV (Oller, 1974; Smith, 1973; Stoel-Gammon & Dunn, 1985).

It is difficult to outline discrete stages of cluster acquisition from the first attempts to final correct production because of the individual variation within children and within cluster types. Studies have shown marked differences in the order of acquisition of clusters as well as in the rate of acquisition (Greenlee, 1973, 1974). Greenlee (1974) suggested four stages in the acquisition of clusters.

Stage 1. Deletion of the entire cluster

Stage 2. Reduction of the cluster to one segment

Stage 3. Substitution of one member of the cluster with the correct number of consonants maintained

Stage 4. Correct production of the target cluster

Children with phonological disorders have particular difficulty with consonant clusters. Stoel-Gammon and Dunn (1985) summarized the results from several studies (Compton, 1975; Dunn & Davis, 1983; Grunwell, 1982; Hodson & Paden, 1981; McReynolds & Elbert, 1981b; Schwartz, Leonard, Folger, & Wilcox, 1980; Shriberg & Kwiatkowski, 1980) and concluded that children with disordered phonology had difficulty with consonant clusters regardless of age, type of analysis, or sampling techniques. Because normal children are also reported to have considerable difficulty with the acquisition

of fricatives (Ferguson, 1978), it would be expected that clusters containing fricatives would present particular problems. In fact, /s/ clusters, particularly /s/ plus stop clusters, are usually among the last clusters mastered (Smith, 1973). Smith (1973) reported the following order of acquisition for his son: 1) /sl/, /sm/, /sn/; 2) /sp/, /sk/; 3) /st/.

Acquisition of a normal phonological system that matches the ambient language is not an all-or-none phenomenon. Instead, gradual acquisition occurs, with some forms produced correctly while some errors are also present. The suppression or disappearance of cluster reduction may be manifested in a gradual emergence of correct forms. Initially, all clusters may be reduced regardless of position within the word. Later, fewer and fewer targets may be reduced until perhaps only final clusters are reduced (Stoel-Gammon & Dunn, 1985). Gilbert and Purves (1977) outlined four possible stages in consonant cluster acquisition. The following example outlines the possible stages in the acquisition of the /bl/ cluster.

Stage 1: blue ---> [bu], one segment is deleted.

Stage 2: blue ---> [bəlu], the cluster is split by epenthesis.

Stage 3: blue ---> [bl:u], the segment previously deleted is produced, but prolonged.

Stage 4: blue ---> [blu], the adult form is realized.

In some cases, the cluster is not reduced by simply omitting one of the consonants and maintaining the other but through substitution of a phoneme not present in the adult form of the cluster. If the substituted phoneme has characteristics or features of both expected phonemes, the process is called coalescence. For example, if /sp/ becomes /f/, the /f/ has the strident or fricative characteristics of /s/ and the labial characteristics of /p/. Edwards and Shriberg (1983) suggested that the process of coalescence could be considered as a case of assimilation followed by deletion, i.e., in /sp/, the /s/ becomes a labial fricative because of the influence of the /p/, and then the /p/ is omitted. Schoenfeld (1985) found coalescence to be quite common in the speech of six phonologically disordered children, as did Dyson and Stewart (1987) and Dyson (1979) in the speech of 40 younger normally developing children. K. Bliele (personal communication, November, 1987) reported a similar finding.

Ingram (1976) described five of the most common reduction patterns for clusters. It must be noted that the actual form of each reduction is dependent upon the type of cluster and its individual segments.

1. In stop plus liquid clusters, the liquid is most often deleted and the stop is maintained, e.g., play ---> [pēɪ].

2. For postvocalic clusters containing liquid plus stop, or liquid plus nasal, the liquid is usually deleted, e.g., help ---> [hɛp].
3. In /s/ plus stop clusters, the /s/ segment is usually deleted, e.g., stop ---> [tɑp].
4. In /s/ plus nasal clusters, the /s/ segment is usually deleted, e.g., smoke ---> [mo͞ʊk].
5. In clusters containing nasal plus obstruent, e.g., /mp/ or /nd/, the reduction occurs in one of two ways: a) if the obstruent is voiced, it is deleted, e.g., stand ---> [stæn]; b) if the obstruent is voiceless, the nasal is deleted, e.g., pink ---> [pɪk].

Generalization of Training

Generalization is the ultimate goal of any phonological remediation program. Stokes and Baer (1977) provided an excellent definition of generalization.

> "The occurrence of relevant behavior under different non-training conditions (i.e., across subjects, settings, people, behaviors, and/or time) without the scheduling of the same events in those conditions as had been scheduled in the training conditions. Thus, generalization may be claimed when no extratraining manipulations are needed for extratraining changes."(p. 350)

Through the routine evaluation of generalization during the remediation program, the child's changing phonological system and the efficacy of therapy procedures can be monitored (Rockman & Elbert, 1984).

Generalization probes

Generalization is usually measured through the use of probes. "A probe consists primarily of behavior not directly trained and is administered at regularly scheduled intervals throughout the course of training" (Rockman & Elbert, 1984, p. 140). In most cases, a small number of items will be chosen from this probe list for training in an effort to monitor the generalization of trained and untrained items. Generalization probes remain constant for each administration because the main purpose of these probes is to measure changes in untrained behaviors across times (Rockman & Elbert, 1984). An additional purpose of probes is to provide the child an opportunity to see the broad range of possibilities for use of a given sound or segment (Elbert, 1983). Use of such probes allows the gathering of information about the child's changing phonological hypotheses and covert knowledge. The probes provide access to the child's covert or underlying phonological system by way of the overt productions. If this covert knowledge is not indirectly identified, it would then become necessary to train the child on every individual utterance (Elbert, 1983) or to simply assume that generalization would take place. Traditionally, the assumption of generalization was made and no effort was made to determine the child's underlying representations of the error phonemes.

Typically, probes are administered imitatively. Studies have found equivalent generalization regardless of the elicitation mode of the stimuli, imitative or spontaneous (Rockman & Elbert, 1984). Use of imitation on generalization probes is often the investigator's attempt to determine the child's "best" production.

Facilitation of generalization

It has been suggested that certain phonetic contexts might facilitate generalization (Kent, 1982). Elbert and McReynolds (1979) studied the effect of phonetic contexts on the generalization of /s/. They considered a variety of contexts, such as high and low vowels, front and back consonants, and front and back vowels. Syllable shapes were also examined. Their results indicated that no particular context was more facilitating for generalization of /s/ than any other. The children studied generalized across many different contexts.

Studies have reported that generalization does indeed occur across word positions (Elbert & McReynolds, 1979; Powell & McReynolds, 1969), to novel untreated words (McLean, 1970; Mowrer, 1971), and to similar but untreated words (Elbert, Shelton, & Arndt, 1967). In the research dealing with across-position generalization, the results indicated that the position of the training target within the word did not have a significant effect on the amount of generalization (Rockman & Elbert, 1984). In other words, the use of

stimulus words with the target form in the initial position is no more or less effective than the use of stimulus words with final position targets. To date, however, no studies have systematically considered the effect of severity of the phonological disorder on the rate or amount of generalization. It is not known whether children with severe impairments will generalize more than those with less severe phonological disorders. The generative phonological studies (Elbert & Gierut, 1986; Gierut, 1985), which attempt to identify a child's phonological knowledge and then base target selection on the results, have most closely looked at the issue of severity and generalization.

Phonological Knowledge

Phonological knowledge has been defined as an individual's covert knowledge or competence about the sound system of a given language. Phonological knowledge refers to those properties of language that are idiosyncratic and often unpredictable as well as to the rules expressing the relationship between sound and meaning (Elbert & Gierut, 1986). Three forms of production data (Table 1) are used to determine phonological knowledge: breadth of the distribution of sounds, use of phonological rules, and nature of the child's lexical representations. The breadth of the distribution of sounds is determined by identification of the phonetic and phonemic inventories. The distribution of sounds in the phonemic inventory by word position and

Table 1. Outline of phonological information necessary to determine level of phonological knowledge.

I. Breadth of the distribution of sounds
   - A. Phonetic inventory
   - B. Phonemic inventory

II. Use of phonological rules
   - A. Static rules or phonotactic constraints
     1. Positional constraints
     2. Inventory related constraints
     3. Sequential constraints
   - B. Dynamic rules
     1. Allophonic rules
     2. Neutralization rules

III. Nature of the child's lexical representations
   - A. Minimal pair data
   - B. Morphophonemic alternations

morphemes is examined to determine if sound contrasts are present across various positions. Phonological rules are divided into two types, static and dynamic. Static phonological rules may be positional, inventory related, or sequential constraints. Dinnsen (1984) referred to the static phonological rules as phonotactic constraints. These rules restrict certain sounds or sequences from occurring in the child's phonetic or phonemic inventories. For example, dynamic rules can be either allophonic rules or neutralization rules. These rules change sound production in specific contexts and can either be optional or obligatory. The nature of the child's lexical representations relies on evidence from minimal pair data or morphophonemic alternations.

The amount and the extent of generalization learning has been reported to be dependent upon the child's phonological knowledge (Elbert & Gierut, 1986). Studies investigating the issue of phonological knowledge have emerged during the past five years (Dinnsen, 1984; Dinnsen & Elbert, 1984; Elbert et al., 1984; Gierut, 1985; Maxwell & Rockman, 1984; Rockman, 1983). Dinnsen and Elbert (1984) studied two sources of data, generative phonological analyses and generalization learning patterns. All subjects exhibited the surface pattern of final consonant deletion but had different generalization patterns following remediation. Closer examination of the subjects revealed that performance was

best on sounds that were phonologically known to the subjects. In other words, "generalization learning on 'known' sounds was superior to generalization learning on 'unknown' sounds" (p. 43). In a similar study, Elbert, Dinnsen, and Powell (1984) found the same results when the process considered was cluster reduction. These findings led the authors to conclude that generalization learning is strongly influenced by a child's phonological knowledge.

Gierut (1985) brought the question of phonological knowledge into the clinical arena with a training study considering the relationship of phonological knowledge to generalization. The effects of varying amounts of phonological knowledge on generalization were investigated. Gierut outlined four profiles what may be exhibited by a child relative to the ambient phonological system. Any one child may be observed to have one or more of these profiles, depending on the child's realizations of any given target.

1. Underlying representations are like those of the ambient language for all target morphemes.
2. Underlying representations are like those of the ambient language for some, but not all targets.
3. Underlying representations are like those of the ambient language for some positions, but not for others.
4. Underlying representations are unlike those of the ambient language in all targets across all positions.

Gierut reported that phonological knowledge could be placed on a continuum of most to least knowledge and that sounds that were placed on the most-knowledge end would show the greatest amount of generalization. Two groups of subjects were trained following opposite protocols. One group was trained on those sounds that represented least-knowledge and the second group received training on the sounds about which they had most-knowledge. The training program involved use of minimal pairs. Two general findings were reported: 1) Generalization was greatest for those sounds about which a child had the most knowledge; 2) Phonological knowledge was reflected in a child's generalization learning. The greatest amount of across the board generalization occurred in the group that received training in the order of least- to most-knowledge. The group that received training from most- to least-knowledge did, in fact, generalize to sounds about which they had most-knowledge. However, for this group, generalization was virtually nonexistent on the sounds about which the children had least-knowledge. Gierut suggested that the analysis of a child's productive phonological knowledge provides one possible way to explain the individual differences in generalization seen across children (Elbert & Gierut, 1986). The Gierut (1985) study served to validate a knowledge continuum and allowed for the development of ranking criteria for determination of phonological knowledge. The nature of

the underlying representation and the breadth of the distribution of sounds are primary in ranking the sounds in a child's phonological system. Based on her findings, Gierut provides questions and a decision tree to assist in the process of ranking a child's phonological knowledge of sounds or sound classes.

In summary, the factor of phonological knowledge appears to account for some of the individual differences seen in generalization learning. The child's phonological knowledge of the adult sound system can be analyzed and shown to consistently explain differences in generalization learning patterns (Elbert & Gierut, 1986).

Statement of the Problem

The purpose of the present study was to examine the effect of severity of phonological disorder on the rate of generalization, using a specific therapeutic program designed to eliminate one phonological process, cluster reduction.

Research Questions

The objectives of this investigation were concerned with phonologically-disordered children and their generalization of /s/ plus stop clusters based on the severity of the phonological disorder. The primary research questions were

1. Will there be differences in the abount of generalization made by subjects based on their severity rating on the Assessment of Phonological

Processes--Revised following an /s/ plus stop cluster training program?

2. Will there be differences in the amount of generalization made by the subjects based on their phonological knowledge following the phonological remediation program?
3. Will there be differences in the amount of generalization made by the subjects when evaluated one month following termination of training?
4. Can differences in amount of generalization be explained by individual differences among children?

Significance of the study

The significance of this investigation lies in the information to be gained regarding the effects of severity upon generalization. The answer to the questions related to the effect of individual differences upon generalization will also be important to the development of remediation goals best suited for each individual child.

CHAPTER II
METHOD

General Overview

In the present investigation, the relationship between severity of phonological disability and generalization learning was examined. Six subjects, with phonological severity ratings of either moderate or severe based on the results of the Assessment of Phonological Processes--Revised, (APP--R) (Hodson, 1986), received phonological remediation aimed at the elimination of cluster reduction, with specific training on the initial /s/ plus stop clusters /sp/ and /st/. Progress during training was measured by the use of generalization probes, with a training criterion of 90% correct across the two clusters for the production training activities. Training was ended after each subject met the training criterion across at least two training sessions. Additionally, a one-month follow-up evaluation, using the same measurements as at the pretraining evaluation, was administered to all subjects. Descriptions of the severity of phonological disability, phonological knowledge, and amount of generalization for each subject and for each group, before and after training, were then made. Results are reported for each subject and for both groups.

Research Design

The optimal research design for this investigation was the multiple baseline across subjects design. There were two severity groups (moderate/severe) determined by the phonological deviancy scores on the APP--R. All subjects received the same treatment on the same /s/ plus stop consonant clusters /sp/ and /st/. Each subject served as a control for the other subjects. To provide a within-subject control, the cluster /br/ was followed in the generalization probes but was not trained.

One subject from each severity group began treatment while the other subjects remained in an extended baseline or no treatment condition. As each subject produced 90% of the target clusters (/sp/ and /st/) across two sessions or completed six training sessions, a new subject began treatment. A schematic of the design is presented below with E representing the evaluation, X representing baseline measurements, and T representing training:

```
S1:  E--X--X--X--T--T--T--T
S2:  E--X--X--X--X--X--T--T--T--T--T--T
S3:  E-X--X--X--X--X--X--X--X--X--X--X--T--T--T--T--T

S4:  E--X--X--X--T--T--T--T--T--T
S5:  E--X--X--X--X--X--X--X--X--X--T--T--T--T--T
S6:  E--X--X--X--X--X--X--X--X--X--X--T--T--T--T--T
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Data analysis included in-depth descriptions of the pretraining and follow-up status of each subject's phonological system. Progress during the training portion of the investigation was also considered.

Subjects

Six children were selected from waiting list at the University of Florida Speech and Hearing Clinic. The first six subjects meeting all selection criteria were chosen. All subjects

1. were between the ages of 3:9 and 5:2 ($\bar{X}$ age = 4:2) at the initiation of the study;
2. came from monolingual English speaking homes;
3. had normal hearing at 20 dB HL for the frequencies 250, 500, 1000, 2000, and 4000 HZ;
4. were clear of active otitis media at the initiation of the study (Dyson, Holmes, & Duffitt, 1987; Paden, Novak, & Kuklinski, 1985);
5. had not been enrolled in treatment for remediation of consonant clusters prior to the initiation of the study;
6. had at least 70% correct production of initial singleton stops /p/, /t/, and /k/ (Leadon, 1987) in spontaneous speech and on the generative phonological assessment;
7. produced the initial /s/ plus stop clusters /sp/ and /st/ with at least 80% cluster reduction as determined by the first baseline probe (Leadon, 1987);
8. demonstrated language skills within normal limits (± 6 months) based on results of the Peabody

Picture Vocabulary Test--Revised, (PPVT--R) and the Preschool Language Scale, (PLS);

9. had normal functioning of the oral speech mechanism as shown by the results of St. Louis and Ruscello (1980) assessment procedure;
10. had at least 25% of stridency deletion on the strident targets from the APP--R and 35% of stridency deletion in the spontaneous speech sample; and
11. scored within the moderate or severe range on the APP--R.

Parental Responsibility

During the first session, the parents were asked to complete a case history form that focused on speech development and hearing status, including history of otitis media. Studies have indicated that children with histories of otitis media often evidence phonological disorders that require remediation (Paden, Novak, & Kuklinski, 1985). Children with such histories have higher levels of deficient patterns than same-aged peers with no histories of otitis media (Dyson, Holmes, & Duffitt, 1987). Children were not excluded from the study because of histories of otitis media. However, these data were considered as individual learning patterns were discussed. Prior knowledge of such histories often provides insight into specific patterns.

At the time of the initial meeting, the purpose of the study was outlined for the subjects' parents. Each parent was instructed to read a letter that fully explained the nature of the study (Appendix A), and was requested to sign a parental consent form that gave permission for the child to participate in the study (Appendix B). Parents were informed that the subjects could be withdrawn from the study at any time. Parents were not required to participate in any other activities during the course of the study, but were invited to observe each session.

Assessment Instruments

Formal Assessment Instruments

The Assessment of Phonological Processes--Revised, (APP--R) (Hodson, 1986) allows for the identification of phonological processes or patterns in the child's speech. Fifty spontaneous single-word responses are elicited through use of pictures and objects. The APP--R tests all English singleton consonants in prevocalic and postvocalic positions and 31 consonant sequences. Patterns of error, called deficient patterns, are identified, and frequency counts of these patterns are calculated. The word list for the APP--R is included in Appendix C.

The Peabody Picture Vocabulary Test--Revised, (PPVT--R), (Dunn & Dunn 1981) is considered an adequate measure of recognition or receptive vocabulary. Thus, for the purposes of this investigation, the PPVT--R was used to measure

receptive vocabulary only. Administration involves picture pointing tasks, with no verbal responses required from the child.

The Preschool Language Scale, (PLS), (Zimmerman, Steiner, & Pond, 1979) is a developmentally-based assessment tool that considers two aspects of early language development, auditory comprehension and verbal ability. The PLS provides normative data for comparison. Administration of the PLS results in calculation of an auditory comprehension age, a verbal ability age, and an overall language age. Subjects are required to complete verbal and reasoning tasks using objects and pictures as stimuli. The PLS is designed to evaluate children between the ages of 1-1/2 and 7 years.

Informal Assessment Instruments

The spontaneous speech sampling involved the techniques of storytelling and retelling, and parallel and interactive play using toys and a picture story. The toys were general, with a focus on no particular phoneme or class of sounds. The story, however, included pictures designed to stimulate production of /s/ plus consonant clusters. Speech productions were analyzed to determine phonetic and phonemic inventories, use of phonological rules, and use of lexical contrasts.

The generative phonological assessment or the "Assessment of Knowledge" was based upon the work of Gierut

(1985), and Elbert and Gierut (1986), and was designed to extend the analysis of a spontaneous speech sample. Three types of analysis data are needed for this assessment procedure: breadth of the distribution, use of phonological rules, and nature of the child's lexical representation. To supplement the spontaneous speech sample, a picture naming task that samples all target English sounds in all possible positions was developed by Gierut. Each sound is presented in several different words, and is presented more than once to determine consistency and variability of production. Opportunities are presented to allow for production of minimal pairs and morphophonemic alternations. The Gierut protocol (1985) contains 300 single word productions.

A subset of Gierut's 300-word sample was used for this investigation, with additional words added to assess initial fricatives and stops, and to contrast prevocalic singleton and cluster productions. The word list for this assessment is included in Appendix D. Because the scope of the study involved training /s/ clusters only, the subset was chosen in an attempt to assess phonological knowledge of clusters and fricative singletons. Minimal or near-minimal pairs made up of initial clusters and singletons, such as stop/top or spin/pin, were used to assess phonological knowledge of clusters. Additionally, the Gierut protocol involves the use of diminutive word forms such as doggie. Many of the words in the final compilation were not true words, but were

used to elicit the intervocalic consonant singletons. Examples include the following diminutive forms: glove-i for glove, chip-i for chip and bridge-i for bridge. The spelling of these diminutive forms remained constant, with the /-i/ added to the end of the spelling to signal the diminutive form.

Materials

Stories and Toys for Spontaneous Speech Sample

A storytelling task was developed using characters from Sesame Street. The story included the /s/ plus stop clusters /sp/, /st/, and /sk/, and other /s/ plus consonant clusters including /sl/, /sn/, and /sm/. Toys, objects, and pictures were chosen for the spontaneous speech sample. The main criteria for selection were that the toys be of interest to preschool children and capable of eliciting spontaneous speech.

Training Words

This study was designed to teach a limited number of exemplars, six per cluster. Recent research (Elbert et al., 1987) has indicated that generalization will occur if fewer exemplars are utilized in training sessions than previously assumed. Initial /sp/ and /st/ consonant cluster words were chosen. Care was taken to control for the part of speech, in that equal numbers of nouns and verbs were chosen for each cluster type. The training words for this study were

/sp/: spoon, spider, spool, spot (Nouns)
spill, spin (Verbs)

/st/: star, stamp, stick, stone (Nouns)
stand, stop (Verbs)

These words were chosen because they could be easily demonstrated and incorporated into communication-based activities. To reduce the influence of other stridents on the production of /s/ plus stop clusters, no stridents other than initial /s/ occurred in any position in the words.

Baseline and Probe Lists

Baseline lists were used to establish stability prior to initiation of training. The words comprising the baseline list are presented in Appendix E. Additionally, probe lists, extracted from the baseline list, were used to assess the generalization learning following each training session on the /s/ plus stop clusters, /sp/ and /st/. Probes were used to evaluate the production of the following phonemes and positions

1. untrained words with the trained targets, initial /sp/ and /st/ clusters;
2. words with initial untrained /sk/ consonant clusters;
3. words containing other initial untrained /s/ plus consonant clusters, /sn/, /sm/, /sl/;
4. words containing initial untrained strident

singletons, /f/, /v/, /s/, /z/, /ʃ/, /ʒ/, /ʧ/, and /ʤ/; and

5. words containing the untrained control cluster, initial /br/.

In an attempt to control for phonetic complexity, only one strident consonant per word was allowed whenever possible. Distractors were included so subjects were not aware of test stimuli, i.e., words that did not contain /s/ clusters or strident singletons were included in the probe lists (Winner & Elbert, 1986). These distractors included words containing the control cluster /br/ to further strengthen the within-subject control for the multiple baseline across subjects design. No reinforcement was given during this imitative task. The subject were directed to "Say these words after me."

Measurement Procedures

Baseline Measurements

Prior to the initiation of treatment, a 172-word baseline probe was administered to each subject. The word list for the baseline is found in Appendix E. This baseline measurement was continued until stability was achieved. For purposes of this investigation, stability was defined as greater than 80% of cluster reduction for the target cluster stimuli, and greater than 30% of stridency deletion on the singleton stimuli. Further, subjects were required to demonstrate no more than 10% overall improvement in cluster

production, and no more than 30% overall improvement in strident productions during the baseline measurements to be included in the study. Words with the following contexts were chosen

1. /sp/ and /st/ clusters
2. /sk/ clusters
3. /s/ plus consonant clusters
4. fricative singletons
5. /br/ clusters

For each administration of the baseline probes, the order of presentation was varied. Imitation of the targets were elicited in the context of a game.

Generalization Measurements

Generalization measurements were administered following each training session. The generalization probes consisted of randomly chosen words from the baseline list, with six different lists generated containing words from each of the following word-initial contexts.

	Context	Number
1.	Untrained words containing initial /sp/ and /st/ clusters	8
2.	Untrained words containing initial /sk/ clusters	4
3.	Untrained words containing initial /sl/, /sn/, and /sm/ clusters	12

4. Untrained words containing initial strident singletons 28

5. Untrained words containing initial /br/ clusters 8

Total 60

The generalization probes were presented in the context of a game, with imitated responses elicited by the examiner requesting that the subject, "Say these words after me." No reinforcement for correct or incorrect production was given during the administration of the probes. Subjects received reinforcement of completion of different sections of the probes. Distractor words that did not contain initial /s/ clusters or fricatives were included in the probes. The word list for the generalization probes is found in the Appendix E.

Training Procedures

Each training session had two phases.

Phase 1: Production Training. The subject was given auditory, visual and tactile cues to facilitate the correct production of /s/ plus stop clusters in the initial position of words. Drill-play activities then required the child to use the target words in the context of a game. Each session included an incorporation of the target words into a communicatively meaningful activity. Stoel-Gammon and Dunn (1985) emphasize the

necessity of incorporating conceptually-based activities into the entire phonological remediation program. When communication breakdowns occur due to the child's production errors, the child must then become aware of the error and attempt to revise the underlying concept. Use of such activities provide the opportunity for the child to observe the communicative impact of correct forms.

Phase 2: Generalization Probe. The generalization probe described above was administered.

Transcription and Organization of Data

Baseline and generalization measurements were audio-taped for later transcription using an Sharp RT-10BK cassette tape recorder and a Realistic PZM, Model 33-1090B microphone. The productions from each subject were transcribed on-line, as well as audio-taped for later transcription.

To determine accuracy of the phonetic transcriptions, two listeners, trained and experienced in the transcription of disordered speech, independently transcribed each utterance, and then compared transcriptions for agreement following the procedures outlined by Shriberg, Kwiatkwoski, and Hoffman (1984). For those segments not agreed upon, consensus was established by replaying the audiotape no more than three times. During each replay, each listener was

directed to attempt to hear the other's transcription, and also to confirm her own transcription. If agreement was not reached at this point, the application of one of 17 consensus rules described by Shriberg, Kwiatkowski, and Hoffman (1984) was made. To determine the reliability of the transcription, a portion of the consensus transcriptions (5% of the total) was selected, and a percentage of agreement was calculated. The percentage of listener agreement for this investigation was 91%.

Analysis of the Data

The three formal assessment instruments were scored following the procedures outlined by the authors of each tool (Dunn & Dunn, 1981; Hodson, 1986; Zimmerman, Steiner, & Pond, 1979). To assure consistency of the examiner's scoring, one-fourth of the test forms were randomly selected and rescored by another speech-language pathologist experienced in assessment. Reliability was 100% for the rescoring of the PPVT--R and the PLS and was 98% for the APP--R.

Cluster productions from the spontaneous speech sample, and the baseline and generalization measurements were scored using a correct versus incorrect dichotomy. A percentage of correct production for each cluster and each initial strident singleton was calculated.

Computer Coding

The generative phonology assessment, spontaneous speech sample, baseline probes, and generalization measurements were coded and sorted for analysis using the Programs to Examine Phonetic and Phonologic Evaluation Records, (PEPPER), (Shriberg, 1986). The PEPPER is a computer software program for use with IBM or IBM compatible computers. The PEPPER allows for a detailed phonetic, phonologic and prosodic examination of speech. PEPPER uses analysis programs called Pepdata that can be performed on group or individual data. The Pepdata Analyses Programs include analysis of: 1) Structural Statistics including word types, average words per utterance, and type token percentages; 2) Phoneme Analysis for consonants and vowels; 3) Feature Analysis for consonant and vowels; 4) Item Analysis; 5) Phonetic Analysis: Percentage of Consonants Correct; 6) Phonetic Analysis: Percentage of Consonants Correct Split; 7) NPA Summary Analysis; 8) NPA: Percentage of Occurrence Summary (POS); 9) NPA: Word Lists.

The data or utterances are entered onto the PEPFILE in three basic forms, the X, Y, and Z lines. The English orthography gloss is entered on the X line. This represents what the examiner thought the child meant to say. Line Y contains the transcription of the intended utterance. Use of broad or narrow transcription is left up to the discretion of the examiner. Finally, the Z line represents

the transcription of the child's productions. The use of PEPPER in the research environment is considered one the strengths of this analysis program. It is an efficient way to collect and analyze a large speech sample in great detail. The PEPPER provides the researcher with a variety of analyses that can be carried out with great speed (Dyson, 1987).

Data Analysis

Question 1: The effect of severity on generalization following cluster training. Data from the APP--R (Hodson, 1986), the generalization measurement probes, and the follow-up sample were used to answer Question 1. The APP--R was used for assignment of subjects into the two severity groups. For each subject, an individual inspection of the probes was made, and any patterns of generalization described.

If severity is, in fact, related to generalization learning, the subjects with the severity rating of moderate should have higher scores on the generalization probes than the severe group. However, if severity is not related to this learning, all subjects should be expected to perform similarly on the probes. Further, if generalization across-clusters does occur, not only would it be expected that the /s/ plus stop clusters, /sp/, /st/, and /sk/ would show generalization to untrained stimuli, but the other untrained /s/ plus consonant clusters would show generalization as

well. The greatest generalization within-clusters, excluding untrained /sp/ and /st/ stimuli, would be expected to occur on untrained /sk/ words because it is the most closely related by manner of production. The only difference in /sp/, /st/, and /sk/ is the place of production of the stop consonant.

Question 2: The effect of phonological knowledge on generalization following cluster training. To determine the relationship between generalization and phonological knowledge, data from the generative phonological assessment and the generalization probes were used. Profiles of phonological knowledge for each subject were described with comparison of pretraining and follow-up knowledge. No formal statistical procedures were used, instead inspection of the data served to describe subject profiles. Based on the Gierut (1985) findings, it was expected that those subjects with least-knowledge should generalize to a broader extent. As outlined in Question 1, similar across-cluster and within-cluster generalization profiles would be expected.

Question 3: The effect of severity on generalization one month following cluster training. To answer Question 3, pretraining and follow-up data for each subject were compared. Follow-up samples included productions from the readministration of the APP--R, the generative phonological assessment, and the generalization measurements. A

comparison of performance on the phonological knowledge continuum was made for each subject.

All subjects would be expected to show improved generalization scores at the one-month follow-up because the literature strongly supports the gradual nature of generalization. The reorganization of the phonological system is not simply an all-or-none phenomenon, rather a gradual sifting through of old patterns and productions and replacing them with the newer, more correct forms. Ingram (1976; 1983) suggested that the child is reorganizing the phonological system, and this restructuring does not occur across the board, but is gradual and may not be evident for several months. If severity is related to generalization, the moderate group should show greater improvement in production of clusters in the one-month follow-up than the severe group. Given the gradual nature of generalization learning (Dyson & Leadon, 1988; Ingram, 1976), it would be expected that there would be significant improvement in cluster production from the pretraining evaluation to the one-month follow-up. If within-cluster generalization occurred during the one-month interim, the words containing untrained /s/ plus stop clusters, including /sk/, should show improved production. If across-cluster generalization, occurred, the untrained /s/ plus consonant clusters should be produced more accurately at the follow-up evaluation than at the initial baseline.

Question 4: The effect of individual differences on the amount of generalization learning. Profiles for each subject were prepared including all assessment data, behavioral observations, and training performance. In-depth descriptions of the performance of each subject over time will be presented.

CHAPTER 3
RESULTS

Overview

The purpose of the present study was to examine the effect of severity of phonological disorder on the rate of generalization, using a specific therapeutic program designed to reduce the occurrence of one phonological process, cluster reduction. This purpose was addressed specifically by measuring the generalization patterns of two groups of phonologically disordered children during training of /s/ plus stop clusters. The primary research questions were:

1. Will there be a difference in the amount of generalization made by the subjects based on their severity rating on the Assessment of Phonological Processes--Revised following an /s/ plus stop cluster training program?

2. Will there be differences in the amount of generalization made by the subjects based on their phonolgical knowledge following the phonological remediation program?

3. Will there be differences in the amount of generalization when evaluated one month following termination of training?

4. Can differences in the amount of generalization be explained by individual differences among children?

The research design chosen for this project was a multiple baseline across subjects design. Children at two levels of severity based on the Phonological Deviancy Scores from the APP--R were included. The two groups represented the severity levels of moderate and severe. All subjects were trained to produce initial /sp/ and /st/ words. To provide a within-subject control, the initial cluster /br/ was followed in the generalization probes but was not trained.

One subject from each severity level began treatment while the other subjects remained in an extended baseline, or the no-treatment condition. As each subject generalized at least 50% of the target clusters (/sp/ and /st/ only) during the production drills across two sessions, or had completed six training sessions, a new subject began treatment. The research design is summarized in Table 2.

The results of the investigation are presented by severity level with Group I representing the subjects with moderate severity levels and Group II, the subjects with severe levels. For each subject, case history information is presented, as are language and hearing functioning levels. The phonological analyses were completed on four sets of data, the initial evaluation, the baseline measurements, the generalization probes (during training), and the follow-up evaluation. Following the presentation of results for each individual subject within a severity group, a brief summary

Table 2. The multiple baseline across subjects research design for two severity levels, moderate and severe, based on results from the APP-R.

	Severity Level I: Moderate
Subject 1:	X---X---X---O---O---O---O
Subject 2:	X---X---X---X---X---O---O---O---O---O---O---O
Subject 3:	X---X---X---X---X---X---X---X---X---X---X---X---O---O---O---O---O---O
	Severity Level II: Severe
Subject 4:	X---X---X---O---O---O---O---O---O---O
Subject 5:	X---X---X---X---X---X---X---X---X---X---X---O---O---O---O---O
Subject 6:	X---X---X---X---X---X---X---X---X---X---X---X---O---O---O---O---O---O

X - Baseline session
O - Treatment session

of the performance of all subjects within that group will be presented. Finally, any group trends or individual differences across all subjects will be discussed.

Group 1: Moderate

Subject 1

Background information

Subject 1, Jordan, was aged 4 years, 0 months at the beginning of the study. He was the product of an unremarkable pregnancy, and all developmental milestones were within the normal range. Jordan was the youngest of two children, with a sister two years older.

Test performance

On the PLS, Jordan achieved an auditory comprehension and verbal ability age of 4:6 (years:months) for an overall language age of 4:6. On the PPVT--R, Jordan achieved an age equivalency of 4:0. Thus, language skills were within normal limits. Pure tone audiometric screening revealed normal thresholds. Tympanometry was not conducted because Jordan had bilateral tympanic tubes that had been in place for about one year. Upon examination by a certified audiologist, it was determined that the tubes were patent. Initial evaluation results are summarized in Table 3.

On the APP--R, Jordan achieved a phonological deviancy score of 34, placing him in the moderate range of severity. A detailed summary of the pretraining performance of Subject 1 on the APP--R can be found in the second column of Table 4.

Table 3. Summary of pretraining test performance for Subjects 1 through 6. Hearing, tympanometry, and oral mechanism exam results were normal for all subjects.

Subject	Age	APP--R Phonological Deviancy Score	PPVT--R Language Age	PLS Language Age
1	4:1	34	4:0	4:6
2	3:10	32	4:1	3:9-3/4
3	3:9	20	3:6	3:9-3/4
4	4:6	40	4:6	4:9
5	4:4	44	5:3	5:1-1/2
6	4:9	55	5:5	5:11-1/4

Table 4. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 1.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	11	11
Consonant Sequence Reduction	40	30
Consonant Singleton Omissions		
Prevocalic	18	7
Postvocalic	0	0
Class Deficiencies		
Stridents	30	26
Velar Obstruents	14	5
Liquid (l)	91	82
Liquid (r,ɝ)	29	33
Nasals	11	0
Glides	50	20
Total	294	212
Mean	29	21
Age Points (CA of 4:0 = 5)	5	5
Phonological Deviancy Score	34	26
Severity Rating	MODERATE	MODERATE

The percentage of occurrence of consonant sequence reduction (including consonant clusters) was 40%, representing the largest percentage in the phonological omission category. Liquid /l/ made up the largest percentage of the class deficiencies at 91%.

Pretraining phonological evaluation

Phonetic inventory. The phonetic inventory (phones used at least twice correctly or incorrectly in any environment) was determined following the procedures outlined by Grunwell (1988). Marginal phones were those that occurred only one time, and are enclosed in parentheses in Table 5. Jordan's phonetic inventory (Table 5) showed a full repertoire of nasals and stops, including the glottal stop /ʔ/. All fricatives, except /θ/, /ð/, and /ʒ/ were present, although /h/ was marginal. The two affricates, /tʃ/ and /dʒ/, were represented, as were the glides /w/ and /j/. The liquid /l/ was present in Jordan's inventory, but /r/ had only marginal representation.

Phonetic realizations of consonant singletons. The singleton realizations of Subject 1 will be described briefly by manner-of-articulation class. The order of presentation will be fricatives, stops, affricates, nasals, liquids, and glides. Phonological rule statements and accompanying examples for Subject 1 are presented in Appendix F.

Stopping was a common process in Jordan's treatment of fricatives (Table 6), with stops replacing initial /f/, /v/,

Table 5. Pretraining phonetic inventory for Subject 1 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v		s z	ʃ		(h)
Affricate				ʧ ʤ		
Approximant	w		l	j (r)		

Table 6. Summary of pretraining phonetic realizations of the fricatives for Subject 1.

Phoneme	Position		
	Initial	Intervocalic	Final
f	b	f	f
v	b ~ bw	v ~ b	v ~ b
θ	b		
ð	d	d	
s	s	s	s
z	z ~ s	z	z
ʃ	ʃ	ʃ	ʃ
ʒ		ʔ	
h	ø ~ h		

/θ/, and /ð/. The fricatives /s/ and /ʃ/ were produced correctly in all positions, and /f/ and /z/ were produced correctly in the intervocalic and final positions. Also, there was one occurrence of correct /f/ in the initial position. Initial /f/ and /θ/ were replaced by [b]. Initial /z/ was realized as [z ~ s] (either [z] or [s]). The fricative /v/ was realized as [b ~ bw] initially, and /ð/ was replaced by [d] initially. Initial /h/ was realized correctly in some examples and omitted (ø) in others. There were no examples of intervocalic /h/ in the data set. The voiced fricative /v/ was realized as [v ~ b] in the intervocalic and final positions. The palatal fricative /ʒ/ was replaced by the glottal stop intervocalically. The fricative /θ/ was replaced by the fricative /f/ in the final position. The phoneme /ð/ was replaced by the stop /d/ in the intervocalic position, just as in the initial realization.

The phonetic realizations of the stop and affricate classes at the pretraining sample are presented in Table 7. The stops /p/, /b/, and /d/ were produced correctly in all positions. The stop /t/ had correct realizations in all positions, however, in the intervocalic position, the correct target alternated with [ʔ]. The velar /k/ was produced correctly in the intervocalic and final positions. The initial realization of /k/ was an alternation between /k/ and /g/. The voiced velar /g/ was produced correctly in the

Table 7. Summary of pretraining phonetic realizations of the stops and affricates for Subject 1.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t
d	d	d	d
k	k ~ g	k	k
g	g	d	g
ʧ	ʃ ~ ʧ	ʃ ~ ʧ	ʧ
ʤ	ʤ	ʤ	ʤ

initial and final positions. The realization in the intervocalic position was [d], however, there was only one example and the stimulus item was unfamiliar to the subject. The word Ziggy was produced as [sɪdɪ]. The affricates had examples of correct productions in all positions. However, initial and intervocalic /ʧ/ and initial /ʤ/ alternated with /ʃ/ resulting in deaffrication.

Jordan's phonetic realizations of the nasals, liquids, and glides are presented in Table 8. The nasals were produced correctly in all positions. The only intervocalic representation of /m/ was in the environment of abutting consonants and was not considered in the analysis. It was, however, produced correctly, e.g., shampoo ---> [dæmbu]. The process of gliding was evidenced in the production of initial liquids. Liquid /l/ was produced correctly in the final position, but was replaced by the labial glide /w/ in the initial position. In the intervocalic position, liquid /l/ was realized as [l ~ d], (either [l] or [d]). Liquid /r/ was replaced by [w] in the initial position and omitted in the intervocalic position. However, because there was only one possible occurrence of liquid /r/ in the intervocalic position, this realization remains unclear. The glide /w/ was realized correctly in the initial position and was replaced by the stop /d/ in the intervocalic position. Whereas, intervocalic /j/ was realized correctly, initial /j/ had the alternating form of [j ~ ∅].

Table 8. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 1.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		m
n	n	n	n
ŋ		ŋ	ŋ
l	w	l ~ d	l
r	w	ø	
w	w	d	
j	j ~ ø	j	

Phonetic realizations of consonant clusters. The only clusters Jordan produced for cluster targets in the pretraining sample were [sw] for /sl/ and [br] and [bw] for /br/. The first column of Table 9 summarizes Jordan's performance on words containing clusters in the adult model. The /s/ plus stop clusters were all reduced to the expected stop. The /s/ plus liquid cluster was realized as [s sw]. The nasal cluster /sn/ was realized as [n ~ b ~ ∅], with /sm/ realized as [m ~ b]. Two correct productions of /br/ (two occurrences of break ---> [brēɪk]) were evidenced, although [bw] served as the most frequent realization. Of the 181 initial consonant clusters expected in the pretraining sample, 33% were produced as clusters, either correct or incorrect. Examples of Jordan's cluster attempts are presented in Appendix F.

Homonyms. Subject 1 produced homonyms for 14% of the pretraining sample set. Intelligibility was only moderately affected by this process of homonymy.

Phonological knowledge. A continuum of phonological knowledge for Subject 1 is presented in Table 10. Phonemes realized correctly in all positions were considered adult-like, and were assigned knowledge Type 1. The Type 1 phonemes from Jordan's sample were /s/, /ʃ/, /p/, /b/, /d/, /m/, /n/, and /ŋ/. The Type 2 phonemes were /z/, /t/, /k/, /ʤ/, and /w/, due to the application of optional rules. Type 3 knowledge is characterized by some correct examples in

Table 9. Cluster realizations for Subject 1 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p	sp ---> sp ~ p
st ---> t	st ---> st ~ t
sk ---> k	sk ---> sk ~ k
sl ---> sw ~ s	sl ---> sl ~ sw ~ s
sn ---> n ~ b ~ ∅	sn ---> sn
sm ---> m ~ b	sm ---> sm ~ m
br ---> bw ~ br	br ---> bw ~ br

Table 10. Phonological knowledge continuum for Subject 1 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n ŋ p b d g s ʃ
	Type 2	t k z ʤ w
	Type 3	f h ʧ j
	Type 4	
	Type 5	v l
Least Knowledge	Type 6	ʒ θ ð r

all positions, but not for all morphemes. Jordan's Type 3 phonemes were /f/, /h/, /tʃ/, and /j/. The phonemes /v/ and /l/ were assigned Type 5 phonological knowledge, with some correct examples in at least one position, but not for all morphemes. Finally, those phonemes not in his phonetic inventory, i.e., /ʒ/, /θ/, /ð/, and /r/ were considered Type 6 or non-adult-like.

Baseline measurements

Jordan's performance across time, beginning with the pretraining evaluation, and including the baseline measurements, the probe measurements, and the follow-up evaluation, is presented in Figures 2, 3, and 4. The percentages of correct cluster production and the percentages of correct initial strident singletons are presented in Figure 2. Performance on the specific training clusters /sp/ and /st/, as well as /sk/ and /br/ is presented in Figure 3. The percentage of actual cluster production, either correct or incorrect, and the percentage of stridency, including clusters, are presented in Figure 4. Actual cluster production is calculated by totaling the number of words that should have been produced with clusters, and dividing this total into the total number of these words a given subject produced with clusters, whether correct or incorrect. For example, the word break produced as [bwēɪk] would be counted as a cluster even though the cluster was not produced correctly because two consonants were present in the

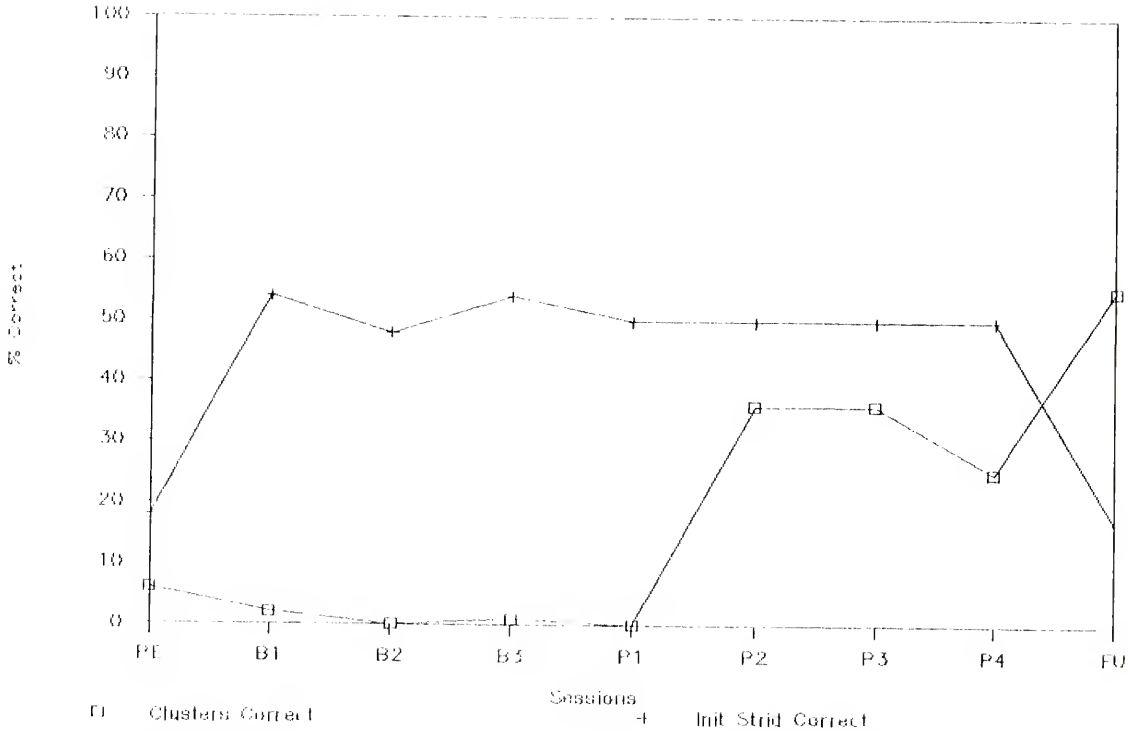

Figure 2. Performance of Subject 1 on correct cluster production and correct initial strident singletons at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation(FU).

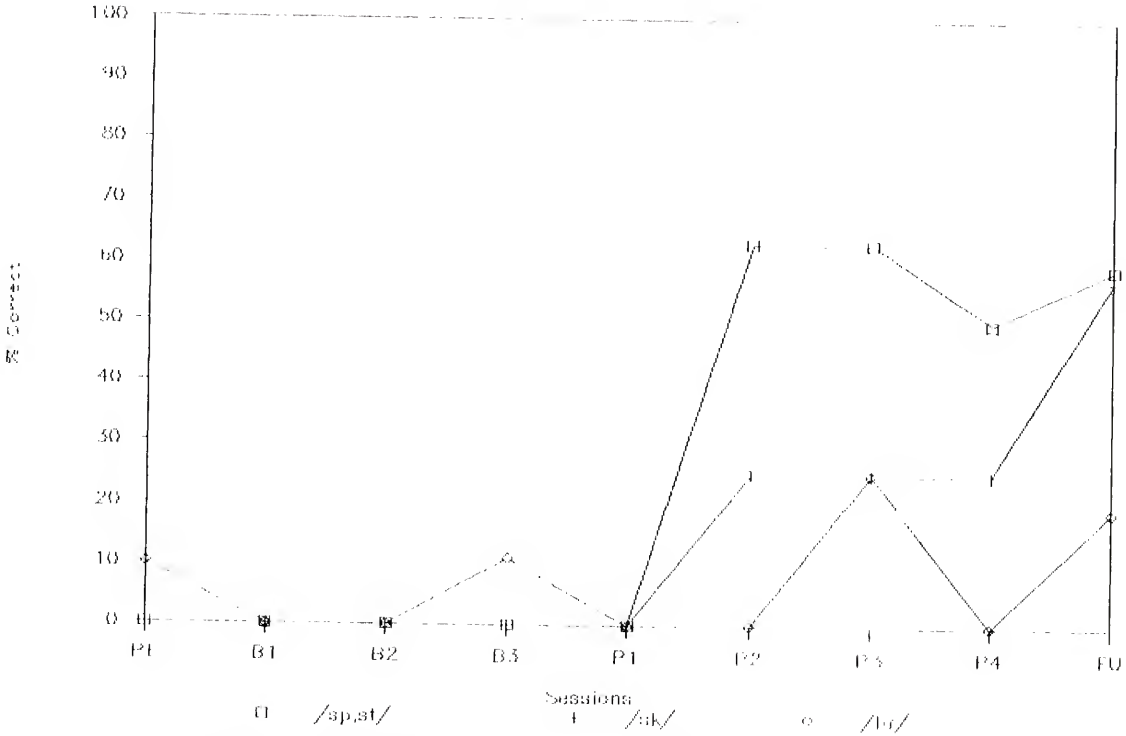

Figure 3. Performance of Subject 1 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

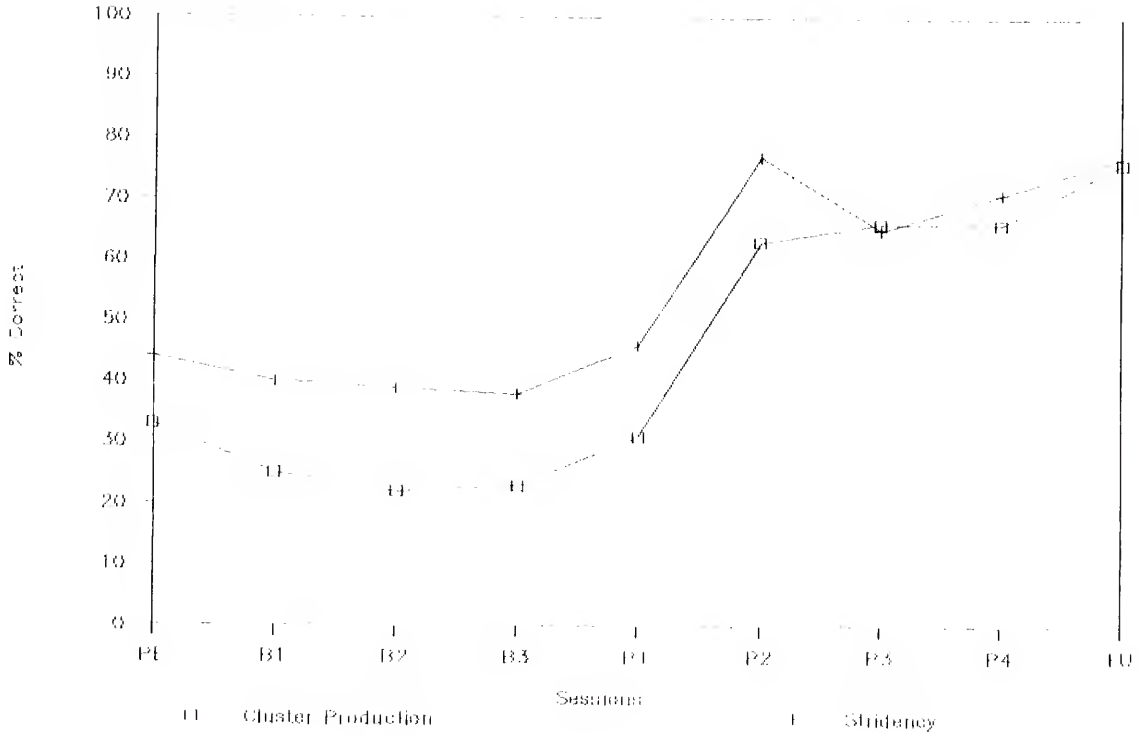

Figure 4. Performance of Subject 1 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

prevocalic position. The percentage of stridency is based on the number of those initial consonants that should have been stridents, including /s/ clusters, that were actually produced as strident consonants, whether or not the strident was correct. For example, the word shake produced as [sēɪk] would be counted as a strident even though the strident was not the correct target. To be counted as an occurrence of stridency production, the phoneme that replaces the target strident must also be a strident.

For Subject 1, three baseline measures were made prior to the initiation of training. Performance remained stable across all three baseline measures. The percentage of correct consonant production remained below 2% for the three measurements (Figure 2). Additionally, the percentage of initial strident singletons (Figure 2) produced correctly did not fluctuate significantly, with 54%, 48% and 54% observed over the three baselines respectively.

No /s/ plus stop clusters (Figure 3) were produced correctly in any of the three baseline measurements. Two correct productions of the control cluster /br/ were produced in Baseline 3 only (Figure 3). No other correct productions were observed across the baselines. Finally, percentages for overall cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed and are presented in Figure 4. Changes in either of these measures could reflect changes in the child's phonological

system not measured by a correct/incorrect dichotomy. Cluster production, correct or incorrect, (Figure 4) remained stable across the three baseline measurements. The percentage of stridency (Figure 4) for those initial consonants that should have been stridents, including /s/ clusters, also remained stable.

Probe measurements

Criterion for termination of training was reached at the fourth session. As seen in Figure 2, overall correct cluster production increased from 0 in Probe 1 to 25% in Probe 4 (Figure 2). Correct strident singleton production, presented in Figure 2, remained stable at 36% correct across all probes.

Generalization to 50% of the target /sp/ and /st/ clusters in untrained words occurred after the second training session (Figure 3). Percentage of correct cluster production of /sp/ and /st/, /sk/, and /br/ are presented in Figure 3. An increase in the correct production of /sp/ and /st/ clusters from 0 at Probe 1 to 50% by Probe 4 was evidenced. Correct production of the /sk/ cluster was stable at 25% from Probe 2 to Probe 4. The control cluster /br/ was not produced correctly in Probes 1, 2, and 4, but a temporary jump to 25% correct occurred in Probe 3.

As seen in Figure 4, actual cluster production, either correct or incorrect, increased from an initial level of 31% in Probe 1 to 66% in Probes 3 and 4. The percentage of

stridency (Figure 4) for those initial consonants that should have been strident, including /s/ clusters increased from 46% at Probe 1 to 72% at Probe 4 with a temporary rise at Probe 2 to 77%.

Follow-up phonological evaluation

Test performance. As indicated in Table 4, improvement was noted in the APP--R scores between the pretraining evaluation and the final administration, some two months later. During the pretraining evaluation, Jordan had a phonological deviancy score of 34 compared to a final phonological deviancy score of 26. Both scores are within the moderate range (20-39).

Consonant sequence reduction remained the highest phonological omission at 30%, compared to a pretraining percentage of 40. Liquid /l/ deficiencies remained the most frequently occurring class deficiency at 82%. A slight regression from 29% to 33% was observed for liquid /r,ɝ/. Improvements were noted in the glides, with a change in percentage of occurrence of glide deficiencies from 50% to 20%.

Phonetic inventory. The final phonetic inventory (Table 11) had changed from the initial inventory only by the addition of /h/ and /r/. In the initial inventory, both phonemes had marginal.

Phonetic realizations of consonant singletons. Phonological rules and accompanying examples are presented in

Table 11. Follow-up phonetic inventory for Subject 1 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v		s z	ʃ		h
Affricate				ʧ ʤ		
Approximant	w		l	j r		

Appendix F. Examples are included only for those realizations that differ from the adult model. Jordan's follow-up phonetic realizations of fricatives are presented in Table 12. At the follow-up, /s/ and /ʃ/ were still produced correctly in all positions. The phoneme /z/ was produced correctly in all positions, although a morpheme-based rule was operating for words containing zip in the base, with the cluster /sw/ appearing in this context, e.g., zip ---> [swɪp]. The labial fricatives /f/ and /v/ were realized correctly in the intervocalic and final positions. In the initial position, overgeneralization of the /s/ plus stop clusters accounted for some realizations of these phonemes, with /f/ realized as [sp ~ p ~ b] and /v/ as [sp ~ b]. The realizations of /θ/ and /ð/ were the same as at the pretraining sample (fricative replaced by a stop) with one exception. Final /θ/ was realized as [f ~ t] at the follow-up compared with /f/ only at the pretraining sample.

The phonetic realizations of the stops and affricates are presented in Table 13. The stops /p/, /b/, /d/, /k/, and /g/ were produced correctly in all positions at the follow-up (Table 13). Initial and intervocalic /t/ were also produced correctly. Overgeneralization accounted for the initial position examples of /t/ and /d/, with one example of /t/ replaced by [st], and one example of /d/ replaced by [sd]. These examples were not included in the phonetic realization due to their limited occurrence. Final /t/ was realized as

Table 12. Summary of follow-up phonetic realizations of the fricatives for Subject 1.

Phoneme	Position		
	Initial	Intervocalic	Final
f	sp ~ b ~ p	f	f
v	sp ~ b	v	v
θ	b		f ~ t
ð	d	d	
s	s	s	s
z	z	z	z
ʃ	ʃ	ʃ	ʃ
ʒ		ʃ	
h	h		

Table 13. Summary of follow-up phonetic realizations of the stops and affricates for Subject 1.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t ~ k
d	d	d	d
k	k	k	k
g	g	g	g
ʧ	ʃ ~ ʧ	ʃ ~ ʧ	ʃ ~ ʧ
ʤ	ʃ ~ ʧ	ʤ ~ ʧ	ʤ ~ ʧ

[t ~ k]. However, the realization of /t/ as [k] appeared to be context-specific occurring only in the environment of [sCV__#], e.g., state ---> [stēik]. The affricate /ʧ/ was realized as [ʃ ~ ʧ] in all three positions, as was initial /ʤ/. Intervocalic and final /ʤ/ were realized as [ʤ ~ ʧ]. Although only two examples were found in the sample, the realization of intervocalic and final /ʤ/ as [ʧ] could be morpheme-specific occurring only in the words bridge-i and bridge.

The phonetic realizations of the nasals, liquids, and glides are presented in Table 14. The nasals were produced correctly in all positions. Realizations for liquid /l/ in the initial and final positions were the same as in the pretraining sample, [w] in the initial position, and [l] for the final target. However, by the follow-up, the intervocalic /l/ was realized correctly instead of as [l ~ d]. The emergence of liquid /r/ was evidenced in the initial realization of [w ~ r]. Intervocalic /r/ continued to be omitted, although there was only one occurrence in the sample, with zero produced as [zi:o]. The realizations of the glides (Table 14) remained the same as those in the pretraining sample.

Phonetic realizations of consonant clusters. By the follow-up evaluation, Subject 1 was producing significantly more correct clusters than at the pretraining. A summary of the cluster realizations at the pretraining and follow-up

Table 14. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 1.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	m	m
n	n	n	n
ŋ		ŋ	ŋ
l	w	l	l
r	w ~ r	ø	
w	w	d	
j	j ~ ø	j	

evaluations for Subject 1 can be found in Table 9. Percentage of correct clusters, presented in Figure 2, went from a pretraining level of 6% to 55% at the follow-up. A summary of correct productions at the follow-up for /sp/ and /st/, /sk/, and /br/ is found in Figure 3. The /s/ plus stop clusters were still produced correctly in some examples and were reduced to the expected stops in others. Correct production of the target /sp/ and /st/ clusters was 59%, compared with the pretraining level of 0. For /sk/, 57% were produced correctly by the follow-up, with no correct productions observed in the pretraining sample. The control cluster /br/, although produced correctly in some examples, alternated with [bw] and [spw]. The latter cluster production may be attributed to overgeneralization of training. The percentage of correct production for /br/ went from the pretraining level of 10% to 19% at the follow-up. Correct production of the target /sl/ alternated with [sw] and [s]. The cluster /sn/ was produced correctly in all examples. For the nasal cluster /sm/, the correct realization was evidenced in some examples, with the target reduced to the nasal [m] in other examples. Percentage of actual cluster production (correct or incorrect) went from 33% to 76% by the follow-up (Figure 4). Examples of Jordan's cluster attempts can be found in Appendix F.

Homonyms. Subject 1 produced homonyms for 10% of the follow-up sample words compared with 14% in the pretraining

sample. Intelligibility was only mildly affected by this process of homonymy.

Phonological knowledge. From the pretraining sample until the follow-up, positive changes in the phonological continuum were evidenced (Table 15). Phonemes moving to Type 1, correct, adult-like knowledge included /h/, which moved from Type 3 phonological knowledge, and /k/, which moved from Type 2 phonological knowledge. The glide /j/ moved from Type 3 to Type 2 at the follow-up. The phonemes /v/ and /l/ changed from Type 5 to Type 4, and /r/ changed from Type 6 to Type 5. Other changes included the phoneme /f/ moving from Type 3 to Type 4, and /ʤ/ moving from Type 2 to Type 4.

Performance summary for Subject 1

For Subject 1, there was a considerable increase in the percentage of correct clusters from the pretraining level of 6% to 55% at the follow-up evaluation. There was a concurrent increase in actual cluster production (either correct or incorrect) from 33% at the pretraining sample to 76% at the follow-up. The production of the target clusters /sp/ and /st/ showed gains of 59% correct at the follow-up compared to 0 correct at the pretraining evaluation. The untrained /s/ plus stop cluster /sk/ went from 0 to 57% over the course of the study. As expected, the control cluster changed less dramatically from 10% to 19%. No significant changes occurred in the percentage of occurrence production of correct strident singletons with 18% correct at the

Table 15. Phonological knowledge continuum for Subject 1 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n ŋ p b d k g s ʃ h
	Type 2	t z j
	Type 3	ʧ
	Type 4	f v ʤ l w
	Type 5	r
Least Knowledge	Type 6	ʒ θ ð

pretraining sample and 17% at the follow-up. However, production of the feature of stridency for strident targets (including /s/ clusters) did increase from 44% to 77%.

Subject 1 did demonstrate positive change following training. There was generalization of /s/ plus stop clusters as a class as evidenced by the increase in correct /sk/ production. Additionally, increases in correct production of other /s/ plus consonant clusters were noted with correct productions of /sl/, /sn/, and /sm/. An increase in stridency did occur following the training, due in part to the improvement in /s/ plus consonant clusters.

Slight changes were observed in phonological knowledge from the pretraining sample to the follow-up. Positive changes occurred in the realizations of the fricatives /v/ and /h/, with /v/ moving from Type 5 to Type 4, and /h/ moving from Type 3 to Type 1. Changes were also noted in the stop /k/, changing from Type 2 to Type 1, and glide /j/, changing from Type 3 to Type 2. The phonemes /f/, /ɔ/, and /w/ moved toward the least-knowledge end of the continuum at the follow-up, with all assigned Type 4 phonological knowledge.

In summary, Subject 1 did produce more clusters, and the feature of stridency did appear to generalize. There was not a significant change in severity level reported on the APP--R because Subject 1 scored in the moderate range for both administrations. However, the phonological deviancy scores

did change, with 34 reported at the pretraining administration and 26 at the follow-up administration. The changes that occurred in the phonological system of Subject 1 can be attributed to the effect of training /s/ plus stop clusters.

Subject 2

Background information

Subject 2, Don, was aged 3 years, 10 months at the beginning of the study. He was the product of an unremarkable pregnancy, and all developmental milestones were within the normal range. Don was the oldest of two children, with an 18 month old brother.

Test performance

On the PLS, Don achieved an auditory comprehension age of 4:0 (years:months) and a verbal ability age of 3:7-1/2 for an overall language age of 3:9-3/4. On the PPVT--R, Don achieved an age equivalency of 4:1. Thus, language skills were within normal limits. Pure tone audiometric screening revealed normal thresholds. Tympanometry revealed some negative pressure at the time of the first meeting. Don's mother reported that he had had a cold during the previous week. Tympanometry was repeated at the second meeting, and normal curves were present. Initial evaluation results are summarized in Table 3.

On the APP--R, Don achieved a phonological deviancy score of 34, placing him in the moderate range of severity. A detailed summary of the pretraining performance of Subject

2 on the APP--R can be found in Table 16. The percentage of occurrence of consonant sequence reduction (including consonant clusters) was 63%, representing the largest percentage in the phonological omission category. Post-vocalic consonant singleton omission was the second most frequently occurring phonological omission at 45%. Stridents, liquid /r,ɝ/, and nasals made up the largest percentage of the class deficiencies with 58%, 57%, and 47%, respectively.

Pretraining phonological evaluation

Phonetic inventory. Don's phonetic inventory (Table 17) contained all three nasal consonants in all positions. All stops occurred in the initial position; however, /d/ did not occur in the intervocalic position and /p/, /t/, /k/, and /ʔ/ were the only final stops. Subject 2 had all fricatives in the initial position. Only /v/, /ʃ/, and /h/ occurred in the intervocalic position and /s/, /z/, and /x/ were the only final fricatives occurring in the inventory. The affricates and glides occurred in the initial and intervocalic positions, and the liquid /l/ occurred in all positions.

Phonetic realizations of consonant singletons. The singleton realizations of Subject 2 will be described briefly by manner-of-articulation class. The order of presentation will be fricatives, stops, affricates, nasals, liquids, and glides. Due to the application of phonological processes in context-specific situations, the descriptions for Subject 2

Table 16. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 2.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	5	0
Consonant Sequence Reduction	63	63
Consonant Singleton Omissions		
Prevocalic	2	2
Postvocalic	45	87
Class Deficiencies		
Stridents	58	63
Velar Obstruents	27	41
Liquid (l)	9	18
Liquid (r,ɝ)	57	29
Nasals	47	47
Glides	30	40
Total	343	386
Mean	34	39
Phonological Deviancy Score	32	39
Severity Rating	MODERATE	MODERATE

Table 17. Pretraining phonetic inventory for Subject 2 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v	θ	s z	ʃ ʒ	x	h
Affricate				ʧ ʤ		
Approximant	w		l	j		

will be based on position rather than individual phonemes. Phonological rule statements and accompanying examples are presented in Appendix G. Don's phonetic realizations of fricatives are summarized in Table 18. In the initial position, Subject 2 had two correct realizations, /ʃ/ and /h/. The phoneme /f/ was realized as [f ~ fw], and /v/ as [v ~ w ~ f ~ bw]. For the alveolar fricatives /s/ and /z/, the realizations were [s ~ j] and [z ~ ʒ ~ ʤ], respectively. The phoneme /θ/ was replaced by [ʧ], although there was only one example of initial /θ/ in the sample. The correct realization of /ð/ alternated with the stop [d] in the initial position. For Subject 2, two processes were evidenced in the intervocalic and final positions of most fricatives. For the intervocalic position, gliding was common, occurring in all targets with intervocalic realizations. This glide production alternated with other realizations in the intervocalic position in the case of /ʃ/. Intervocalically, /ʃ/ was realized as the glide [w] or was omitted (∅). Additionally, there was one occurrence of correct /v/ production in the intervocalic position; however, it was not considered in the analysis. In the final position, final consonant deletion occurred in all targets. For final /s/ and /θ/, the fricatives were replaced by [ʔ] or omitted. Additionally, one occurrence of final /s/ and /z/ was evidenced in the sample set.

Table 18. Summary of pretraining phonetic realizations of the fricatives for Subject 2.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f ~ fw	w	ø
v	v ~ w ~ bw ~ f	w	ø
θ	ɬ		ʔ ~ ø
ð	d ~ ð	w	
s	s ~ ʃ	w	ø
z	z ~ ʒ ~ ʤ	w	ø
ʃ		w ~ ø	ø
ʒ		w	
h	h		

All stops (Table 19) were produced correctly in the initial position. The phonemes /b/, /k/, and /g/ were also realized correctly in the intervocalic position. As with the fricatives, gliding occurred in the intervocalic realizations of the stops /p/, /t/, and /d/. Intervocalic /p/ and /t/ had one occurrence of the correct targets. This was the only possible occurrence of intervocalic /t/. The /d/ phoneme was replaced by the glide only. Final consonant deletion was evidenced in the realization of all final stops, serving as the sole realization for the voiced stops. The voiceless stop /p/ had the realization of [ø ~ p], with /t/ realized as [ø ~ ʔ ~ x], and /k/ as [ø ~ ʔ ~ x ~ k].

The affricates (Table 19) were produced correctly in the initial position, with /tʃ/ also produced correctly in the intervocalic position. The realization of intervocalic /ʤ/ was unclear with three phonemes [ʤ ~ ʃ ~ w] represented, as well as the omission of intervocalic /ʤ/. Final consonant deletion was also an active process for affricate production, with the final affricates omitted.

The phonetic realizations of the nasals, liquids, and glides for Subject 2 are presented in Table 20. The nasals /m/ and /n/ were produced correctly in the initial positions. Intervocalic /n/ and /ŋ/ were replaced by the glide [w], with final /n/ realized as [ø ~ n]. There was one occurrence of correct /n/ in the intervocalic position. In the final position, /m/ was omitted and final /n/ was produced

Table 19. Summary of pretraining phonetic realizations of the stops and affricates for Subject 2.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	w	ø ~ p
b	b	b	ø
t	t	t	ø ~ ʔ ~ x
d	d	w	ø
k	k	k	ø ~ ʔ ~ k ~ x
g	g	g	ø
ʧ	ʧ	ʧ	ø
ʤ	ʤ	ʤ ~ ʃ ~ w ~ ø	ø

Table 20. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 2.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		ø
n	n	w	ø ~ n
ŋ		w	ø ~ ŋ ~ n
l	l	l ~ w ~ j	l ~ v ~ ø
r	w	w	
w	w	w	
j	j ~ w ~ ø	w	

correctly in some examples and omitted in others. The realization of final /ŋ/ was [ø ~ ŋ ~ n]. Liquid /l/ was produced correctly in the initial position. Correct realization of /l/ also occurred in the intervocalic and final positions, although intervocalic /l/ alternated with the glides [w ~ j]. The target was also vowelized or omitted in the final position. The liquid /r/ was replaced by the glide /w/ in the initial and intervocalic positions. The glide /w/ was produced correctly in the initial and intervocalic positions. The palatal glide /j/ was realized as [j ~ w ~ ø] in the initial position, and was replaced by /w/ in the intervocalic position.

Phonetic realizations of consonant clusters. The only clusters Don produced for pretraining cluster targets in the pretraining sample were [sl] and [sl] for /sl/, and [bw] and [br] for /br/. The phonetic realizations of the consonant clusters for Subject 2 are presented in Table 21. As shown in Figure 5, 17% of all clusters occurring in the sample were produced correctly. The /s/ plus stop clusters were all reduced to the expected stops. Stridency was evident in the /s/ plus liquid and /s/ plus nasal clusters, with /sl/ realized as [s̲l ~ sl ~ ʃ], /sn/ as [ʃ ~ s], and /sm/ as [f ~ ʃ ~ m]. The control cluster /br/ was realized as [bw], although there was one correct production of /br/ in the sample. There was also one example of [b] replacing /br/. Examples of the cluster attempts are presented in Appendix G.

Table 21. Cluster realizations for Subject 2 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p	sp ---> p ~ sp
st ---> t	st ---> st ~ t
sk ---> k	sk ---> k ~ sk
sl ---> s̲l ~ sl ~ ʃ	sl ---> sl
sn ---> ʃ ~ s	sn ---> n ~ ʃ ~ s ~ sn
sm ---> f ~ ʃ ~ m	sm ---> n ~ f ~ sm
br ---> bw ~ br	br ---> br ~ bw

Homonyms. Subject 2 produced homonyms for 39% of the pretraining sample set. This percentage resulted in significant interference with overall intelligibility, and can be attributed in part, to the processes of gliding and final consonant deletion.

Phonological knowledge. A continuum of phonological knowledge for Subject 2 is presented in Table 22. Phonemes realized correctly in all positions were considered adult-like, and were assigned knowledge Type 1. The Type 1 phonemes from Don's sample were /h/ and /w/. Don's Type 3 phonemes were /p/, /k/, /n/, and /l/, with some examples correct in all positions, but not for all morphemes. The phonemes /ʃ/, /b/, /t/, /d/, /g/, /ʧ/, /ʤ/ and /m/ were assigned Type 4 phonological knowledge. Type 5 phonological knowledge is characterized by some correct examples in at least one position, but not for all morphemes. Don's Type 5 phonemes were /f/, /v/, /s/, /z/, /ð/, /ŋ/, and /j/. Finally, the phonemes not in Don's phonetic inventory, i.e., /ʒ/, /θ/ and /r/, were considered Type 6 or non-adult-like.

Baseline measurements

Don's performance across time, beginning with the pretraining sample and including all measures through the follow-up, is presented in Figures 5, 6, and 7. For Subject 2, five baseline measurements were taken prior to the initiation of training. Performance remained stable for all baseline measures. As indicated in Figure 5, Don produced

Table 22. Phonological knowledge continuum for Subject 2 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	h w
	Type 2	
	Type 3	n p k l
	Type 4	m b t d g ʃ ʧ ʤ
	Type 5	ŋ f v s z ð j
Least Knowledge	Type 6	ʒ θ r

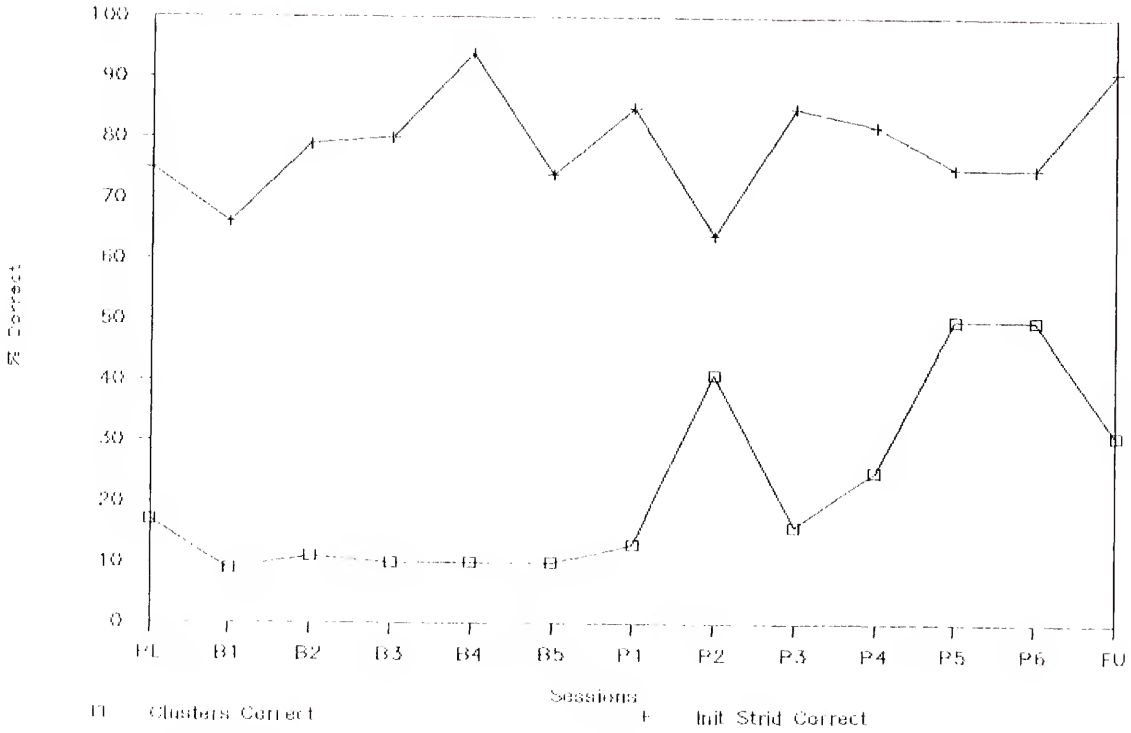

Figure 5. Performance of Subject 2 on correct cluster production and correct initial strident singletons at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

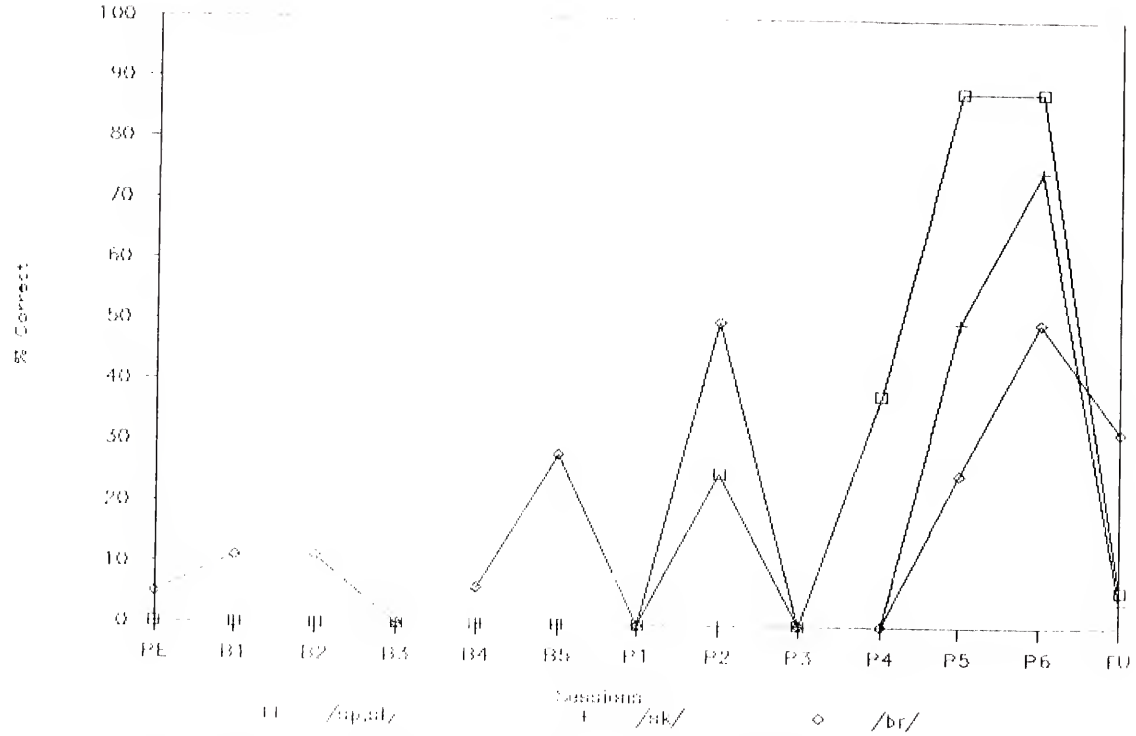

Figure 6. Performance of Subject 2 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

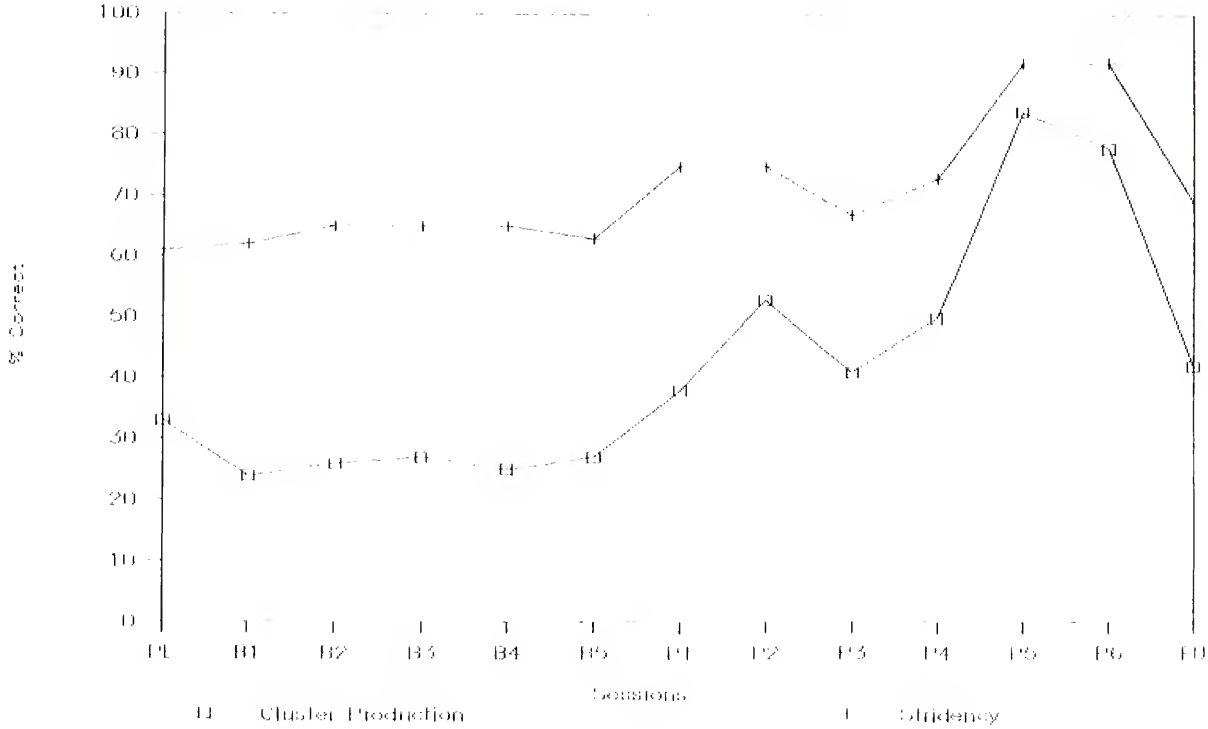

Figure 7. Performance of Subject 2 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

correct clusters during each baseline measurement with a range of 9% to 11%. The percentage of initial strident singletons produced correctly increased from 66% at Probe 1 to 74% at Probe 5. The highest percentage of correct production of the strident singletons occurred in Baseline 4, with 94% of these singletons produced correctly (Figure 5).

Percentages of correct production for the clusters /sp/ and /st/, /sk/, and /br/ are presented in Figure 6. No /s/ plus stop clusters were produced correctly during any of the baseline measurements. The control cluster /br/ was produced sporadically, with a range of 0 to 28%. Finally, percentages for overall actual cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed, and are presented in Figure 7. Changes in either of these measures could reflect changes in the child's phonological system not measured by the correct/incorrect dichotomy. Cluster production (correct or incorrect) remained stable across the five baseline measurements. The percentage of stridency for those initial consonants that should have been stridents, including /s/ clusters, also remained stable.

Probe measurements

Subject 2 had six training sessions before criterion for termination was met. As shown in Figure 5, correct cluster production increased from 13% in Probe 1 to 50% at the sixth and final probe. Further, correct production of the initial

strident singletons (Figure 6) was above 50% on all probes, with a high of 85% at Probes 1 and 3 and a low of 64% at Probe 2.

The percentages of accuracy for the specific clusters /sp/ and /st/, /sk/, and /br/ are presented in Figure 6. An increase in the correct production of /sp/ and /st/ clusters was observed across the probes, moving from 0 at Probe 1 to 88% at Probe 6; however, performance fluctuated widely. The /s/ plus stop cluster /sk/ did not emerge until Probe 5, with 50% observed for Probe 5 and 75% correct for the sixth and final probe. Correct production of /br/ occurred in Probes 2, 5 and 6 with 50%, 25%, and 50% correct, respectively.

The summary of performance for stridency and cluster production can be found in Figure 7. The percentage of stridency present for those initial consonants that should have been strident, including /s/ clusters, evidenced increases from a 75% level in Probe 1 to 92% by Probe 6. Additionally, percentage of actual cluster production (correct or incorrect) was high in Probe 5 at 84% and low in Probe 1 at 38%. Steady increases were observed over time.

Follow-up phonological evaluation

Test performance. As indicated in Table 16, a regression was noted on the APP--R scores from the pretraining evaluation until the final administration, some two months later. During the initial evaluation, Don had a phonological deviancy score of 34 compared to a final phonological

deviancy score of 39. Both scores are within the moderate range, however.

Postvocalic consonant singleton omissions replaced consonant sequence reduction as the most frequently occurring phonological omission, with an increase from a pretraining level of 45% to 87% at the follow-up. Consonant sequence reduction remained at 63%. Stridents remained the most frequently occurring class deficiency at 63%, compared to the pretraining level of 58%. Increases in percentage of occurrence were also observed for velar obstruents, liquid /l/, and glides. Improvements were noted in the liquid /r,ɝ/, with a change in percentage of occurrence of liquid /r,ɝ/ deficiencies from 57% to 29%. The percentage of occurrence of nasal class deficiencies remained the same at 47%.

Phonetic inventory. The phonetic inventory for Subject 2 had changed from the pretraining sample in two ways. The fricative /θ/, absent in the pretraining sample, was marginal by the time of the follow-up. Additionally, the velar fricative /x/ was no longer present in the phonetic inventory. All other aspects remained constant. The phonetic inventory at the follow-up evaluation for Subject 2 can be found in Table 23.

Phonetic realizations of consonant singletons. Phonological rules and accompanying examples are presented in Appendix G. Examples are included only for those real-

Table 23. Follow-up phonetic inventory for Subject 2 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v	(θ)ð	s z	ʃ ʒ		h
Affricate				ʧ ʤ		
Approximant	w		l	j		

izations that differ from the adult model. Much change had occurred in the realizations of the fricatives by Subject 2 at the time of the follow-up (Table 24). As before, no single fricative was realized correctly in all positions. The phonemes /f/, /v/, /z/, /ʃ/, /h/ and /θ/ were produced correctly in the initial position. For initial /s/ and /ð/, the realizations remained the same as at the pretraining evaluation, [s ~ ʃ] for /s/ and [ð ~ d] for /ð/. Gliding continued to be evidenced in all intervocalic realizations, with the exception of /θ/ and /ʒ/. No examples of /θ/ involving singletons were observed, and intervocalic /ʒ/ was replaced by [ʃ]. Intervocalic /f/ was replaced by the glide [w]; the intervocalic /v/ maintained the same realization as at the pretraining evaluation, [w ~ v]. The emergence of stridency was noted in the production of the intervocalic alveolar fricatives. The fricative /s/ had changed its pretraining intervocalic realization of [w] by the addition of several phonemes, [w ~ s ~ z ~ ʃ ~ b]. Intervocalic /z/ was realized as [w ~ z ~ ʒ] compared to [w] only at the pretraining evaluation. Additionally, final consonant deletion continued as an active process for Subject 2. Omissions of the targets occurred with all the final fricatives. Single examples of correct production for final /f/ and /s/ were evidenced in the data set.

The realizations for initial stops (Table 25) remained the same as that of the pretraining sample with all produced

Table 24. Summary of follow-up phonetic realizations of the fricatives for Subject 2.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f	w	ø
v	v	w ~ v	ø
θ	θ		ø
ð	ð ~ d		
s	ʃ ~ s	w ~ s ~ z ~ ʃ ~ b	ø
z	z ~ ʒ	w ~ z ~ ʒ	ø
ʃ	ʃ	ʃ ~ w	ø
ʒ		ʃ	
h	h		

Table 25. Summary of follow-up phonetic realizations of the stops and affricates for Subject 2.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p ~ b	ø ~ ʔ ~ p
b	b	b	ø
t	t	w	ø ~ ʔ
d	d	d	ø
k	k	k ~ g	ø ~ ʔ ~ k
g	g	g	ø
ʧ	ʧ	ʧ ~ g ~ ʃ	ø ~ ʔ
ʤ	ʤ	ʤ ~ ʒ	ø

correctly. The process of gliding had decreased in frequency by the follow-up. The voiced phonemes /b/ and /g/ were produced correctly in the intervocalic position. For intervocalic /p/, the realization was [p ~ b], and there was no change from the pretraining sample for intervocalic /t/, with /t/ replaced by [w]. For /k/, the realization in the intervocalic position was [k g]. As with the fricative class, final consonant deletion was evidenced in the realization of the stops. The voiced stops were always omitted in the final position. For /p/ and /k/, the targets were produced correctly, omitted, or replaced by [ʔ]. For the phoneme /t/, the target was omitted or alternated with [ʔ], with no correct productions noted. Changes were noted in Don's realizations of the affricate class (Table 25), although considerable variation was still evident. The correct production of the initial affricates continued to the follow-up evaluation. However, intervocalic /ʧ/ changed from a correct realization to [ʧ ~ g ~ ʔ]. Final /ʧ/ continued to be omitted, but by the follow-up, the glottal stop replaced /ʧ/ in some examples. Intervocalic /ʤ/ changed from [ʤ ~ ʃ ~ w ~ ø] to [ʤ ~ ʒ], and final /ʤ/ continued to be omitted.

The phonetic realizations of the nasals, liquids, and glides are presented in Table 26. The labial nasal /m/ was produced correctly in the initial and intervocalic positions, and the velar /ŋ/ was produced correctly in the medial

Table 26. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 2.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	m	ø ~ m
n	n	n ~ w	n ~ ø
ŋ		ŋ	ø
l	l	l	l ~ ø
r	w	w	
w	w	w	
j	j ~ ʤ ~ ø	ʤ	

position. In the final position, /m/ was produced correctly in some examples and omitted in others. The alveolar nasal /n/ was realized correctly in the initial position and in some examples in the final position, although final consonant deletion was also noted for final /n/. The intervocalic /n/ was realized as [n ~ w ~ g]. The velar /ŋ/ was omitted in the final position. Changes were evidenced for the realizations of liquid /l/. Whereas initial /l/ remained the same with correct productions, intervocalic /l/ changed from [l ~ w ~ j] to [l] only. Final /l/ moved from [l ~ V ~ Ø] to [l ~ Ø], with the absence of vowelization of /l/ by the follow-up. The realization of /r/ in the initial and intervocalic positions remained the same, with the glide /w/ replacing the target. The glide /w/ was correctly produced in the initial and intervocalic positions, as in the pretraining sample. For initial /j/, the realization had become [j ~ ʤ ~ Ø] compared to a pretraining realization of [j ~ w ~ Ø]. Intervocalic /j/ changed from [w] to [ʤ].

Phonetic realizations of consonant clusters. The summary of Don's cluster realizations at the follow-up is presented in Table 21. By the follow-up, Subject 2 was producing more correct clusters (Figure 5). The percentage of correct cluster production went from a pretraining level of 17% to 31% at the follow-up. Performance on the clusters /sp/ and /st/, /sk/, and /br/ is presented in Figure 6. The /s/ plus stop clusters were produced correctly in some

examples, and were reduced to the expected stop in others. The control cluster /br/ alternated with [bw] at the follow-up, with 42% produced correctly compared to a pretraining level of 5%. By the follow-up, /sl/ was produced correctly in all examples. The /s/ plus nasal clusters were realized correctly in some examples, and alternated with [n ~ ʃ ~ s] in the case of /sn/, and with [m] in the case of /sm/. The percentage of cluster production, correct or incorrect, (Figure 7) was 42% up from a pretraining level of 33%. Examples of Don's cluster attempts are presented in Appendix G.

Homonyms. Subject 2 produced homonyms for 37% of the follow-up sample set compared with 39% at the pretraining evaluation. Intelligibility remained affected by this large proportion of homonymy. Final consonant deletion and gliding of intervocalic consonants remained active processes by the follow-up.

Phonological knowledge. From the pretraining sample until the follow-up evaluation, changes had occurred in the phonological knowledge continuum (Table 27). All phonemes showing change moved toward the most-knowledge end of the continuum. The phoneme /m/ moved from Type 4 to Type 2 and /l/ from Type 3 to Type 2 at the follow-up. The fricative /s/ was assigned Type 3 phonological knowledge at the follow-up. Three phonemes, /f/, /v/, and /ŋ/, changed from Type 5 to Type 3. Finally, /θ/ moved from Type 6 to Type 4.

Table 27. Phonological knowledge continuum for Subject 2 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	h w
	Type 2	m l
	Type 3	n p k s
	Type 4	ŋ b t d g f v θ ʃ ʧ ʤ
	Type 5	s ʒ j
Least Knowledge	Type 6	ʒ r

Performance summary for Subject 2

Subject 2 did show changes in performance over the course of training. However, the changes were slight in most instances. Correct cluster production increased from a pretraining level of 17% to 31% by the follow-up. Slight increases occurred in the level of overall cluster production (either correct or incorrect) from 33% to 42%. Whereas some correct /s/ plus stop clusters were evidenced by the follow-up, the increase was negligible. For the training targets /sp/ and /st/, there was an increase from 0 to 6%. The untrained /sk/ increased from 0 to 4% by the follow-up. The production of correct strident singletons increased from 75% to 91%. Additionally, the feature of stridency changed from the pretraining level of 61% to 69% at the follow-up. This slight increase was due in part to the low percentage levels for /s/ plus consonant clusters.

Several changes were evidenced in the phonological knowledge continuum between the pretraining evaluation and the follow-up sample. The fricatives /s/, /f/, /v/, and /θ/ showed positive changes, moving toward the most-knowledge end of the continuum. Additionally, /m/ and /l/ were assigned Type 2 phonological knowledge by the follow-up, compared to Type 4 knowledge for /m/ and Type 3 for /l/ at the pretraining sample.

The scores from the APP--R changed slightly, with a pretraining phonological deviancy score of 34 and a follow-up

score of 37. This decrease in performance was due in part to increased occurrence of postvocalic consonant singleton omissions.

Although Subject 2 did make changes that could be attributed to the training of /s/ plus stop clusters, the changes were slight. The cluster /sl/ was the only /s/ plus consonant cluster produced correctly in all examples by the follow-up.

Subject 3

Background information

Subject 3, Andy, was aged 3 years, 9 months at the beginning of the study. He was the product of a difficult birth. Medical reports indicated that Andy was born with the umbilical cord wrapped around him. However, all developmental milestones, with the exception of speech and language, were within normal limits. Speech and language milestones were somewhat delayed, with babbling reported at 1-1/2 years, first words at 2 years, and word combinations at 2-1/2 years. Andy has a history of colds and middle ear infections beginning shortly after birth. Pressure equalization tubes were placed in Andy's ears in 1986, and his adenoids were removed the same year. The tubes were not in place at the time of the study. Andy is the oldest of two children, with a younger brother, 10 months of age. Andy's mother was also expecting a third child at the time of the study.

Test performance. On the PLS, Andy achieved an auditory comprehension age of 4:1-1/2 (years:months) and a verbal ability age of 3:6 for an overall language age of 3:9-3/4. On the PPVT--R, Andy achieved an age equivalency of 3:6. Thus, language skills were within normal limits. Pure tone audiometric screening revealed normal thresholds. Tympanometry also revealed normal middle ear functioning. Initial evaluation results are summarized in Table 3.

On the APP--R, Andy achieved a phonological deviancy score of 20, placing him in the moderate range of severity. A detailed summary of the pretraining performance for Subject 3 the APP--R can be found in Table 28. The percentage of occurrence of consonant sequence reduction (including cluster reduction) was 28%, representing the largest percentage in the phonological omission category. Liquid /l/ deficiencies made up the largest percentage of the class deficiencies with 82% occurrence.

Pretraining phonological evaluation

Phonetic inventory. Andy's phonetic inventory (Table 29) included the full complement of stops, nasals, glides, liquids, and affricates. All fricatives were present, with the exceptions of /θ/, /ð/, and /ʒ/ that were marginal.

Phonetic realizations for consonant singletons. The singleton realizations of Subject 3 will be described briefly by manner-of-articulation class. Phonological rule statements and the accompanying examples for each sound are

Table 28. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 3.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	11	5
Consonant Sequence Reduction	28	18
Consonant Singleton Omissions		
Prevocalic	5	0
Postvocalic	6	0
Class Deficiencies		
Stridents	19	12
Velar Obstruents	14	9
Liquid (l)	82	73
Liquid (r,ɝ)	10	0
Nasals	16	11
Glides	10	0
Total	201	128
Mean	20	13
Phonological Deviancy Score	20	13
Severity Rating	MODERATE	MILD

Table 29. Pretraining phonetic inventory for Subject 3 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	
Fricative	f v	(θ) (ð)	s z	ʃ (ʒ)		h
Affricate				ʧ ʤ		
Approximant	w		l	j r		

presented in Appendix H. The phonetic realizations of the pretraining fricatives are presented in Table 30. The fricatives /f/, /v/, /s/, and /z/ were produced correctly in all positions. The phoneme /h/ was produced correctly in the initial position, and /ʒ/ was produced correctly in the intervocalic position. No productions in other positions occurred in the sample for these two targets. The palatal fricative /ʃ/ was realized as [ʃ ~ s] in all three positions. The phoneme /θ/ was realized as [g] in the initial position and [f ~ θ] in the final position. Finally, /ð/ was replaced by /d/ in the initial and intervocalic positions. No word productions containing /θ/ in the intervocalic position or /ð/ in the final position were evidenced.

All stops (Table 31), affricates (Table 31), and nasals (Table 32) were produced correctly in all positions. Additionally, the glides /w/ and /j/ (Table 32) were produced correctly in the initial and intervocalic positions. The phonetic realizations of the pretraining liquids are presented in Table 32. Liquid /r/ was produced correctly in the initial and intervocalic positions, as was liquid /l/ in the intervocalic and final positions. In the initial position, the process of gliding was evidenced, with liquid /l/ replaced by the glide /w/.

Phonetic realizations of consonant clusters. Andy's phonetic realizations of the clusters at the pretraining are presented in Table 33. The clusters Andy produced for

Table 30. Summary of pretraining phonetic realizations of the fricatives for Subject 3.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f	f	f
v	v	v	v
θ	g		f ~ θ
ð	d	d	
s	s	s	s
z	z	z	z
ʃ	ʃ ~ s	ʃ ~ s	ʃ ~ s
ʒ		ʒ	
h	h		

Table 31. Summary of pretraining phonetic realizations of the stops and affricates for Subject 3.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t
d	d	d	d
k	k	k	k
g	g	g	g
ʧ	ʧ	ʧ	ʧ
ʤ	ʤ	ʤ	ʤ

Table 32. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 3.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	m	m
n	n	n	n
ŋ		ŋ	ŋ
l	w	l	l
r	r	r	
w	w	w	
j	j	j	

Table 33. Cluster realizations for Subject 3 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p	sp ---> sp ~ p
st ---> t	st ---> st ~ t
sk ---> k	sk ---> sk ~ k
sl ---> sw ~ s ə w	sl ---> sw
sn ---> sw ~ s ə w	sn ---> sw
sm ---> s ə w ~ sw	sm ---> sw ~ sm
br ---> br	br ---> br ~ sbr

cluster targets in the pretraining sample were [sw] for /sl/, /sn/ and /sm/, and [br] for /br/. The /s/ plus stop clusters were reduced to the expected stops. The control cluster /br/ was produced with 96% accuracy, and therefore, provided little control for this subject. In addition, an epenthetic /ə/ was inserted between /s/ and /w/ as realizations for /sl/, /sn/, and /sm/. Of the expected 169 initial consonant clusters in the pretraining sample, 33% were produced as clusters, either correct or incorrect. Examples of Andy's cluster productions are presented in Appendix H.

Homonyms. Subject 3 produced homonyms for 9% of the pretraining sample set. Intelligibility was not adversely affected by the process of homonymy.

Phonological knowledge. A continuum of phonological knowledge for Subject 3 is presented in Table 34. Most phonemes were considered adult-like, and were assigned Type 1 phonological knowledge. These included all stops, glides, affricates, and nasals, as well as the liquid /r/, and all the fricatives with the exception of /ʃ/, /θ/, and /ð/. The fricative /ʃ/ was placed in the Type 3 category, with some correct productions in all positions, but not for all morphemes. Liquid /l/ was placed in the Type 4 category, corresponding to adult-like representations in some word positions for all target morphemes, with some positional constraints evidenced. The phoneme /θ/ was assigned Type 5 phonological knowledge, with some correct productions in the

Table 34. Phonological knowledge continuum for Subject 3 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n p b t d k g f v s z ʒ h tʃ dʒ w j r
	Type 2	
	Type 3	ʃ
	Type 4	l
	Type 5	θ
Least Knowledge	Type 6	ð

final position, but not for all morphemes. Finally, the lingual-dental fricative /ð/ did not occur in Andy's inventory, and was considered Type 6, non-adult-like.

Baseline measurements

The performance of Subject 3 on cluster production and stridency is illustrated in Figures 8, 9, and 10. For Subject 3, 11 baseline measurements were made prior to initiation of training. Performance remained stable for all baseline measures. As indicated in Figure 8, correct cluster production remained stable over all baseline measures with a range of 17% to 19%. Additionally, the correct production of initial strident singletons (Figure 8) remained stable with one exception. Whereas the range of correctly produced strident singletons was 90% to 99% for most probes, there was a temporary drop at Probe 2 to 87%.

Performance summaries for the clusters /sp/ and /st/, /sk/, and /br/ are presented in Figure 9. The /s/ plus stop targets /sp/ and /st/ had three occurrences of correct production, one at the second, the fifth, and the seventh baselines, with 3% correct at each of baselines. No other correct productions of /s/ plus stop clusters were evidenced. The /br/ control cluster was correctly realized in all words from Baseline 2 until the end of training.

Percentages for overall cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed and are presented in Figure 10.

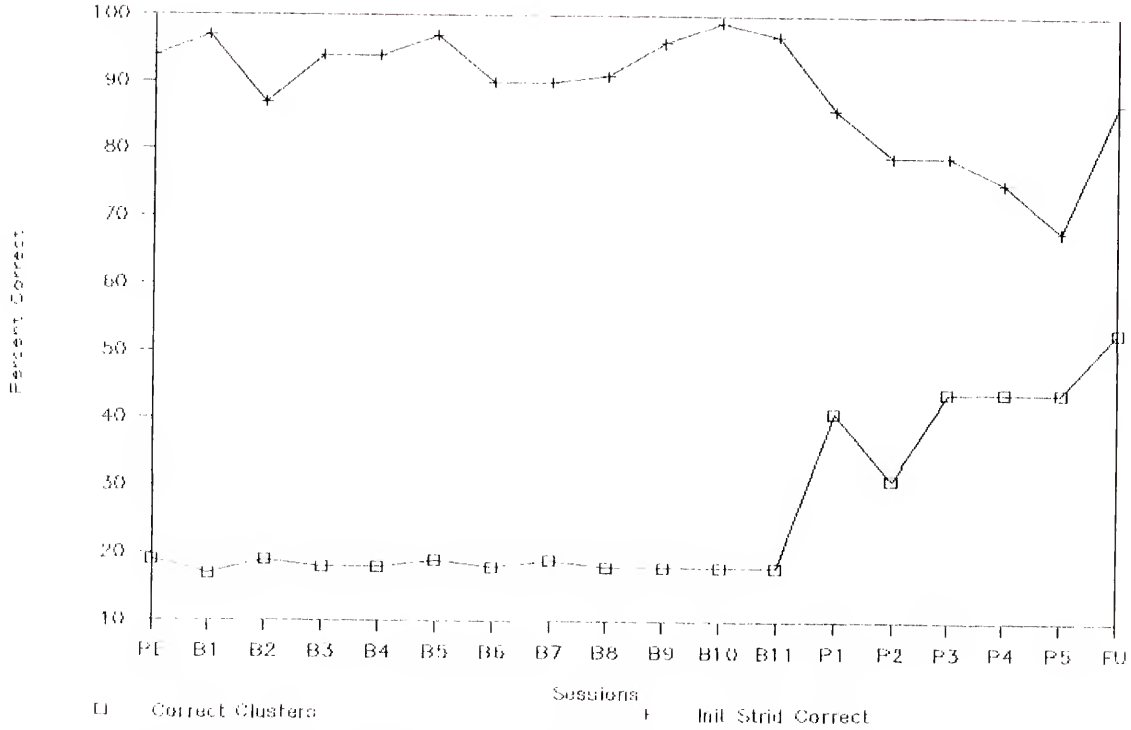

Figure 8. Performance of Subject 3 on correct cluster production and correct initial strident singletons at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

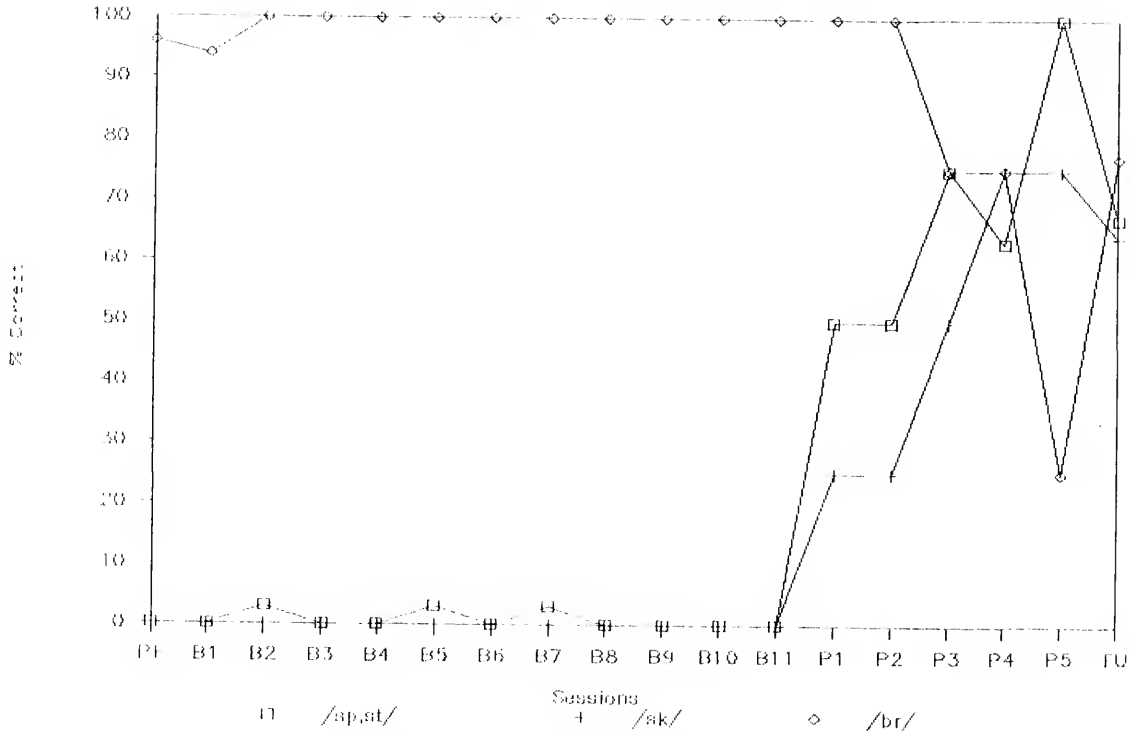

Figure 9. Performance of Subject 3 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

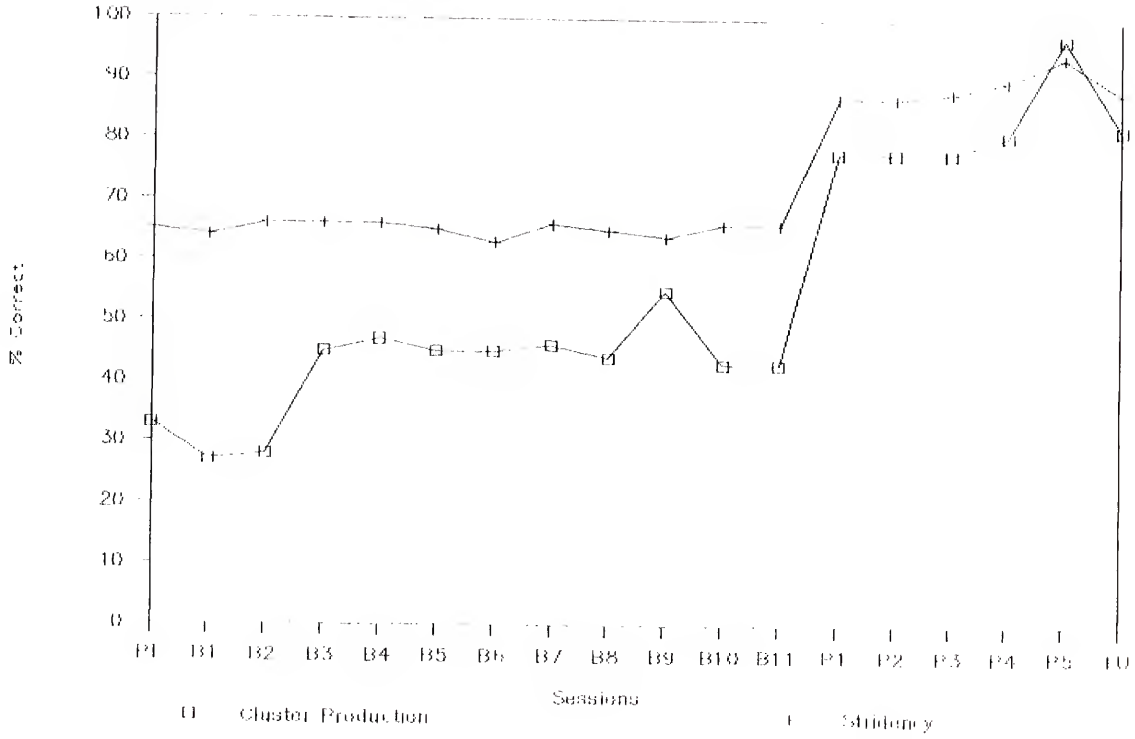

Figure 10. Performance of Subject 3 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

Overall cluster production increased from 27% to 43% at the eleventh and final probe. The percentage of stridency for those initial consonants that should have been produced as stridents, including /s/ clusters, remained stable across the eleven baselines.

Probe Measurements

Criterion for termination of the training of the target /sp/ and /st/ clusters was reached after the fifth training session. As indicated in Figure 8, increases in correct cluster production resulting from the correct production of /s/ plus stop clusters were offset by the decrease in accuracy of the control cluster /br/. Correct production of initial strident singletons (Figure 8) dropped with a low of 68% at Probe 5 and a high of 86% at Probe 1.

Performance measures for correct cluster production of the targets /sp/ and /st/, /sk/, and /br/ during this period are presented in Figure 9. There was an increase in correct production of the /sp/ and /st/ targets from 50% at Probe 1 to 100% correct at the fifth and final probe. The other /s/ plus stop cluster /sk/, also showed an increase from 25% at the initial probe to 75% by Probe 5. An interesting change in /br/ occurred during the course of training, with a drop in correct production from an initial 100% at Probe 1 to 25% at Probe 5 that could be attributed to overgeneralization of training. Target words containing /br/ were produced with an added initial /s/, e.g., break was realized as [sbrēik].

Andy's performance on overall cluster production and overall stridency is presented in Figure 10. The percentage of actual cluster production increased from 78% at Probe 1 to 97% at the fifth and final probe. Little change was seen in the feature of stridency across the probes.

Follow-up phonological evaluation

Test performance. As indicated in Table 28, improvement in the APP--R scores was observed between the pretraining phonological deviancy score of 20 and the follow-up phonological deviancy score of 13. The increase in the score moved Andy from the moderate (20-39) to mild (1-19) range of severity. Consonant sequence reduction and liquid /l/ deficiencies continued to represent the highest percentages of occurrence. However, both had dropped by the follow-up evaluation.

Phonetic inventory. The only changes in Andy's phonetic inventory (Table 35) from pretraining to the follow-up evaluation were in the status of the fricatives /θ/ and /ð/. These phonemes were marginal in the pretraining inventory, but were present completely in the follow-up sample.

Phonetic realizations for consonant singletons. Phonological rule statements and accompanying examples for Subject 3 are presented in Appendix H. The phonetic realizations of the fricatives at the follow-up are presented in Table 36. No changes were evidenced in the realizations of /v/, /s/, /z/, /h/, or /ʒ/ at the time of the follow-up. These

Table 35. Follow-up phonetic inventory for Subject 3 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	
Fricative	f v	θ ð	s z	ʃ (ʒ)		h
Affricate				ʧ ʤ		
Approximant	w		l	j r		

Table 36. Summary of follow-up phonetic realizations of the fricatives for Subject 3.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f ~ sf	f	f
v	v	v	v
θ	θ	θ	θ ~ f
ð	d ~ ð	d	
s	s	s	s
z	z	z	z
ʃ	ʃ ~ s	ʃ	ʃ ~ s
ʒ		ʒ	
h	h		

phonemes were produced correctly in all positions. Initial /f/ was produced correctly in some examples, and was produced with /s/ preceding the fricative /f/ in other examples. This change should be considered an artifact of training, i.e., overgeneralization of the /s/ plus stop cluster. The phoneme /ʃ/ had the same realization in the initial and final position as present at the pretraining sample, [ʃ ~ s]. However, by the follow-up, /ʃ/ was correctly realized in the intervocalic position. The fricative /θ/ was correctly realized in all positions; however, in the final position, /θ/ alternated with /f/. This final position realization of /θ/ was the same in the pretraining sample. The voiced /ð/ target alternated with /d/ in the initial position, and was realized as /d/ only intervocalically.

Andy's phonetic realizations of the stops and affricates are presented in Table 37. There was no change in /p/, /b/, /t/, /k/, or /g/ from the pretraining sample to the follow-up with all phonemes produced correctly in all positions. The phoneme /d/ was produced correctly in the initial and intervocalic positions. However, the realization of final /d/ had changed from /d/ only to the realization of either the correct production or the omission of the target. This final position change represented the only change for the stop class of consonants. At the pretraining sample, the affricates were produced correctly in all positions. However, by the follow-up, changes had occurred in this sound

Table 37. Summary of follow-up phonetic realizations of the stops and affricates for Subject 3.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t
d	d	d	d ~ ø
k	k	k	k
g	g	g	g
ʧ	ʧ ~ sʧ	ʧ	ʧ
ʤ	ʤ ~ sʤ	ʤ	ʤ

class (Table 37). Intervocalic and final affricates were produced correctly as in the pretraining sample. However, the initial realizations changed by the addition of /stʃ / and /sdʒ / to the /tʃ / and /dʒ / targets, respectively. This should be considered overgeneralization of training of /s/ plus stop clusters.

The phonetic realizations of the nasals, liquids, and glides are presented in Table 38. Realizations of the nasals were the same as at the pretraining sample. Liquid /r/ was produced correctly in the initial and intervocalic positions, as at the pretraining evaluation. Liquid /l/ showed no change in the initial and final positions, but the intervocalic position changed from the pretraining realization of /l/ to a follow-up realization of [w∼ l]. Realizations of the glides were the same as that of the pretraining sample.

Phonetic realizations for consonant clusters. Andy's cluster realizations at the follow-up are presented in Table 33. Whereas the only correct target cluster production at the pretraining evaluation was /br/, many more correct clusters were produced at the follow-up (Figure 8). The percentage of occurrence for correct clusters changed from a pretraining level of 19% to 53% at the follow-up. Performance at the follow-up evaluation on the clusters /sp/ and /st/, /sk/, and /br/ can be found in Figure 9. The /s/ plus stop clusters were still reduced to the expected stop.

Table 38. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 3.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	m	m
n	n	n	n
ŋ		ŋ	ŋ
l	w	l ~ w	l
r	r	r	
w	w	w	
j	j	j	

However, these stops also alternated with the correct cluster forms. The targets /sp/ and /st/ moved from 0 correct at the pretraining sample to 67% at the follow-up. For /sk/, the follow-up level was 64% compared with the pretraining level of 0. Overgeneralization accounted for the change in /br/. At the pretraining level, /br/ was correctly realized, but by the follow-up, /br/ was realized as [br ~ sbr] with 77% correct. The /sl/ cluster was realized as /sw/ as compared to [sw ~ səw] in the pretraining sample. The cluster /sn/ was replaced by [sw] and the cluster /sm/ was realized as [sm ~ sw]. The percentage of cluster production (correct or incorrect) changed from a pretraining level of 33% to 82% by the follow-up (Figure 10). Examples of cluster productions at the follow-up can be found in Appendix H.

Homonyms. Subject 3 produced homonyms for 3% of the follow-up sample set compared to 9% at the pretraining evaluation. Production of homonyms did not interfere with intelligibility.

Phonological knowledge. From the pretraining sample until the follow-up evaluation, considerable change had occurred in the knowledge continuum (Table 39). Three fricatives /f/, /θ/, and /ð/ showed change. The phoneme /f/ changed from a correct realization, Type 1 knowledge, at the pretraining evaluation to Type 2 because of the presence of an optional rule in the initial position. The lingual-dental fricative /ð/ was added to Andy's inventory at the follow-up

Table 39. Phonological knowledge continuum for Subject 3 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n ŋ p b t k g v s z ʒ h w j r
	Type 2	d f θ ʤ ʧ
	Type 3	ʃ
	Type 4	l
	Type 5	ɻ
Least Knowledge	Type 6	

and was placed in the Type 5 category. The voiceless /θ/, was assigned Type 2 knowledge at the follow-up, moving from Type 5 at the pretraining. Some change was evident for /d/, the only stop with realizations differing from pretraining to the follow-up. The /d/ phoneme moved from Type 1 to Type 2 phonological knowledge because of an optional final consonant deletion rule. Finally, the affricates moved from correct realization, Type 1 knowledge, at the time of the pretraining evaluation, to Type 2 knowledge due to overgeneralization of training.

Performance summary for Subject 3

For Subject 3, the percentage of correct clusters increased significantly from the pretraining level of 19% to 53% by the follow-up. The production of clusters (either correct or incorrect) increased from 33% to 82%. The trained /s/ plus stop clusters /sp/ and /st/ were produced correctly 67% of the time by the follow-up, compared with no correct productions at the pretraining sample. The untrained /sk/ cluster moved from 0 correct to 64% at the final evaluation. The control cluster /br/ had decreased in accuracy by the follow-up due to an overgeneralization of the stridency feature. The percentage of correct initial stridents decreased from 94% to 87% by the follow-up. However, the feature of stridency increased across the sample, with clusters included from 65% to 88%.

Some changes were noted in the phonological continuum between the pretraining sample and the follow-up. The phonemes /f/, /d/, /ʧ/, and /ʤ/ moved from Type 1, correct, to Type 2, due to overgeneralization of training. This overgeneralization resulted in the application of optional rules. The lingual-dental fricatives had moved toward the most-knowledge end of the continuum, with /θ/ changing from Type 5 to Type 2 knowledge, and /ð/ changing from Type 6 to Type 5 knowledge.

The phonological deviancy scores from the APP--R for Subject 3 improved from the pretraining level of 20 to 13 by the follow-up. At the pretraining evaluation, Subject 3 was in the high moderate category and by the follow-up, was in the mild severity range.

The phonological system of Subject 3 did undergo changes over the course of training. The changes in cluster production, particularly the /s/ plus stop clusters, can be attributed to the training. It appears that the feature of stridency did generalize to untrained productions because of the increase in correct production of /s/ plus consonant clusters. An interesting artifact of the training is the decrease in accuracy of the cluster /br/ because of the addition of the strident phoneme /s/ to the initial position.

Performance Summary for Group 1: Moderate

Increases in the production of correct clusters were evidenced by all three subjects with a range of 31% to 55%.

This reflects increases of between 13% and 49%. Whereas Subjects 1 and 3 demonstrated significant increases in the production of /s/ plus stop clusters (with increases of between 59% and 67%), Subject 2 did not show these large increases in correct productions. For Subject 2, the /sp/ and /st/ clusters were produced with 6% accuracy (up 6% from the pretraining sample), and /sk/ was produced with 4% accuracy (up 4% from the pretraining sample).

In summary, all three subjects in Group 1 showed increases for the target parameters, /s/ plus consonant cluster production and stridency. Differences in the proportion of correct productions were evidenced across the three subjects. However, it can be stated that there was a positive response to the training across the three subjects as evidenced by generalization measures.

Group 2: Severe

Subject 4

Background information

Subject 4, Polly, was aged 4 years, 6 months at the beginning of the study. She was the product of a difficult birth, with her mother on medication for diabetes during the pregnancy. Polly was born with congenital cataracts, and had corrective surgery for this problem in 1984. She presently wears corrective contact lenses or glasses. Her corrected vision is within normal limits. All developmental milestones were within the normal range, with the exception of speech.

Polly is the youngest of two children, with one sister four years older.

Test performance

On the PLS, Polly achieved an auditory comprehension age of 4:10-1/2 (years:months) and verbal ability age of 4:7-1/2 for an overall language age of 4:9. On the PPVT--R, Polly achieved an age equivalency of 4:6. Thus, language skills were within normal limits. Pure tone audiometric screening revealed normal thresholds with one exception, 25 dB at 4000 Hz. Tympanometry revealed normal middle ear functioning. Initial evaluation results are summarized in Table 3.

On the APP--R, Polly achieved a phonological deviancy score of 41, placing her in the severe range (40-59). A detailed summary of performance for Subject 4 on the APP--R can be found in Table 40. The percentage of occurrence of consonant sequence reduction (including consonant clusters) was 85%, representing the largest percentage in the phonological omission category. Stridents, liquid /r,ɝ/, and liquid /l/ made up the largest percentage of the class deficiencies with 67%, 55%, and 100%, respectively.

Pretraining phonological evaluation

Phonetic inventory. Polly's phonetic inventory (Table 41) included the full repertoire of nasals, stops, affricates, and glides. Alveolar fricatives were present, as well as the palatal fricative /ʃ/ and the glottal fricative /h/. Marginal phones included the fricatives /f/, /v/, and

Table 40. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 4.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	5	5
Consonant Sequence Reduction	85	80
Consonant Singleton Omissions		
Prevocalic	0	0
Postvocalic	6	0
Class Deficiencies		
Stridents	67	53
Velar Obstruents	9	5
Liquid (l)	55	55
Liquid (r,ɝ)	100	95
Nasals	16	11
Glides	20	30
Total	362	334
Mean	36	34
Age Points (CA of 4:0 = 5)	5	5
Phonological Deviancy Score	41	39
Severity Rating	SEVERE	MODERATE

Table 41. Pretraining phonetic inventory for Subject 4 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	
Fricative	(f) (v)	(θ)	s z	ʃ		h
Affricate				ʧ ʤ		
Approximant	w		l	j		

/ð/. Finally, the liquid /l/ was present in Polly's inventory, but liquid /r/ was not.

Phonetic realizations of consonant singletons. The singleton realizations of Subject 4 will be described briefly by manner-of-articulation class. Phonological rule statements and accompanying examples are presented in Appendix I. Fricative realizations (Table 42) were most frequently affected by stopping to a homorganic stop, or gliding to /j/. The fricatives were often correct; however, stopping of fricatives occurred in the realizations of /f/ and /v/ in the initial, intervocalic, and final positions, /θ/ in the initial and final positions, and /ð/ in the initial position. Gliding was evidenced in the initial realizations of /s/, /z/, and /ʃ/. Additionally, initial /s/ and /z/ had some examples of correct production in all positions. However, initial /s/ alternated with [j sj] and final /s/ alternated with [ʔ]. Initial and intervocalic /z/ alternated with [j]. Final /z/ alternated with [ʃ] or was omitted. The realizations for initial /ʃ/ were [j ~ ʃ], with intervocalic and final /ʃ/ realized as [s ~ ʃ]. Finally, initial /h/ and intervocalic /ŋ/ were both produced correctly.

Phonetic realizations of the stops and affricates are presented in Table 43. The stops /b/, /d/, /k/, and /g/ were produced correctly in all positions, as were /p/ in the final position and /t/ in the initial position. A voicing contrast

Table 42. Summary of pretraining phonetic realizations of the fricatives for Subject 4.

Phoneme	Position		
	Initial	Intervocalic	Final
f	p ~ b	p	p
v	b	b	b
θ	b ~ t		f ~ p
ð	d		
s	j ~ s ~ sj	s	s ~ ʔ
z	j ~ z	z ~ j	z ~ ø ~ ʃ
ʃ	j ~ ʃ		s ~ ʃ
ʒ		dʒ	
h	h		

Table 43. Summary of pretraining phonetic realizations of the stops and affricates for Subject 4.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p ~ b	p ~ b	p
b	b	b	b
t	t	t ~ d	t ~ ø
d	d	d	d
k	k	k	k
g	g	g	g
ʧ	t	j	
ʤ	d	z	s ~ ʧ ~ ʃ

was not present in the realizations of initial and intervocalic /p/ that were realized as [p ~ b]. Intervocalic /t/ was realized as [t ~ d] and final /t/ was either produced correctly or omitted. Polly had different realizations for each of the affricates (Table 43), although there were parallel productions of the initial affricates. The voiceless affricate /ʧ/ was realized as the closest stop /t/ in the initial position with the same process of deaffrication occurring for initial /ʤ/. Intervocalic /ʧ/ was replaced by the glide [j] or by [ʔj]. Final /ʧ/ became [ʃ]. For intervocalic /ʤ/, the realization was [z] and final /ʤ/ had the realization of [s ~ ʧ ~ ʃ].

Polly's phonetic realizations of the nasals, liquids, and glides at the pretraining are presented in Table 44. The alveolar nasal /n/ was produced correctly in all positions. The labial /m/ was realized correctly in the initial position, and as [m ~ n ~ Ø] in the final position. The sample data did not contain examples of singleton /m/ in the intervocalic position. Final /ŋ/ was realized correctly, and was replaced by [k] in the intervocalic position. Liquid /l/ was produced correctly in all positions. Gliding was evidenced in the realization of liquid /r/ with /w/ replacing the target phoneme in the initial and intervocalic position. The glides /w/ and /j/ were produced correctly in the initial and intervocalic positions (Table 44).

Table 44. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 4.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		m ~ n ~ ∅
n	n	n	n
ŋ		k	ŋ
l	l	l	l
r	w	w	
w	w	w	
j	j	j	

Phonetic realizations of consonant clusters. The cluster realizations for Subject 4 are presented in Table 45. The only cluster Polly produced for cluster targets in the pretraining sample was one correct production of the /sl/ target. Therefore, the occurrence of correct cluster production was stable at or near 0. The /s/ plus stop clusters were all reduced to the expected stop. In addition, /sp/ was replaced by the voiced labial stop /b/ in some examples. This corresponds to Polly's realization of singleton /p/, [p~b]. The control cluster /br/ was reduced to the expected stop. The /s/ plus liquid cluster /sl/ was usually replaced by /l/, although one correct /sl/ production was evidenced. The /s/ plus nasal clusters /sn/ and /sm/ were reduced to the expected nasal. Examples of Polly's cluster attempts are presented in Appendix I.

Homonyms. Subject 4 produced homonyms for 26% of the pretraining sample. Intelligibility was significantly affected by the process of homonymy. The phonological process of stopping contributed to this loss of contrasts.

Phonological knowledge. A continuum of phonological knowledge for Subject 4 is presented in Table 46. Phonemes realized correctly in all positions were considered adult-like, and were assigned knowledge Type 1. The Type 1 phonemes from Polly's sample were /h/, /b/, /d/, /k/, /g/, /n/, /l/, /w/, and /j/. The fricatives /s/, /z/, and /ʃ/ were placed in Type 3 category along with the stops /p/ and

Table 45. Cluster realizations for Subject 4 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p ~ b	sp ---> p ~ sp
st ---> t	st ---> t ~ st
sk ---> k	sk ---> k ~ sk
sl ---> l ~ sl	sl ---> l
sn ---> n	sn ---> n
sm ---> m	sm ---> m
br ---> b	br ---> b

Table 46. Phonological knowledge continuum for Subject 4 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	n b d k g h w j l
	Type 2	
	Type 3	m p t s z ʃ
	Type 4	ŋ ɣ ð
	Type 5	
Least Knowledge	Type 6	f v θ ɬ ʤ r

/t/ and the nasal /m/. Type 3 phonological knowledge is characterized by correct production of some, but not all morphemes in all positions. The phonemes /ð/ and /ŋ/ were considered Type 4 phonological knowledge, characterized by the presence of positional constraints with correct production of the target in at least one position. Those phonemes not in Polly's phonetic inventory were considered Type 6 or non-adult-like. These included /f/, /v/, /ʒ/, /θ/, /ʧ/, /ʤ/, and /r/.

Baseline measurements

Polly's performance across time, beginning with the pretraining evaluation through the follow-up, is illustrated in Figures 11, 12, and 13. Three baseline measurements were made prior to the initiation of training. Polly was the first subject to receive therapy in the severe group. Performance on correct cluster production (Figure 11) remained stable for all baseline measures. The percentage of initial strident singletons (Figure 11) produced correctly did not fluctuate significantly with a range of 3% to 7% observed across the baselines. No /s/ plus stop clusters or control clusters, (br), were produced correctly during any of the measurements (Figure 12).

The percentages for overall cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed and are presented in Figure 13. Overall cluster production remained stable across the three

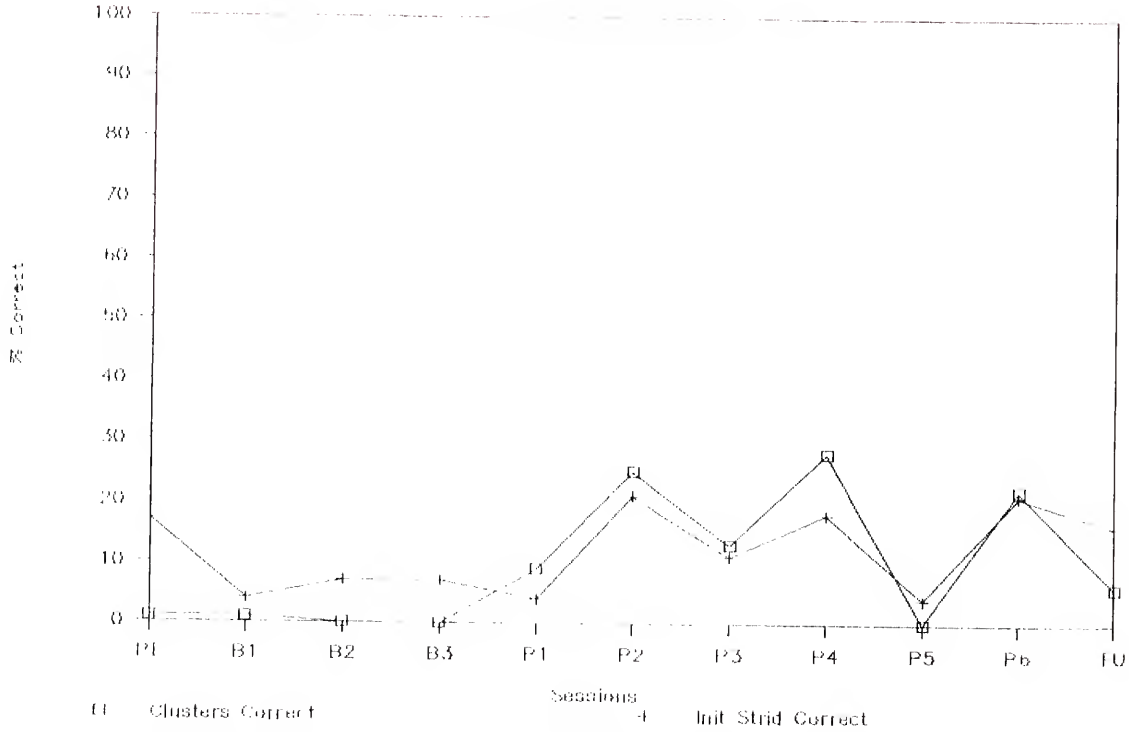

Figure 11. Performance of Subject 4 on correct cluster production and correct initial strident singletons at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

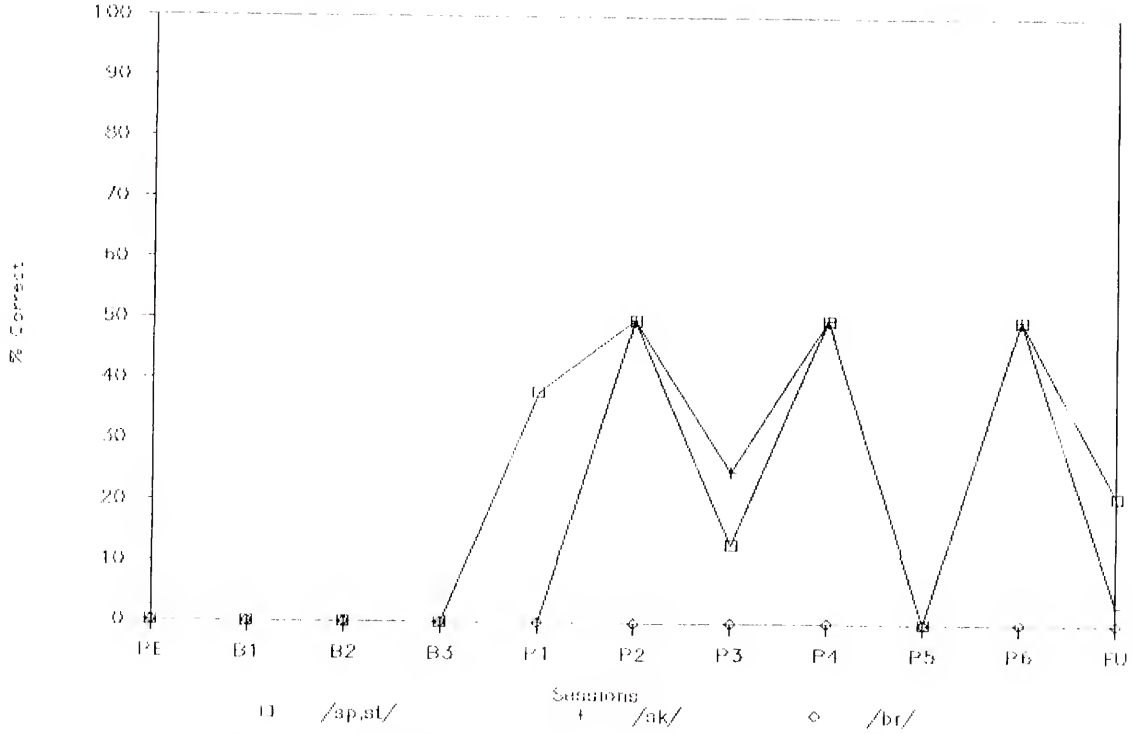

Figure 12. Performance of Subject 4 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

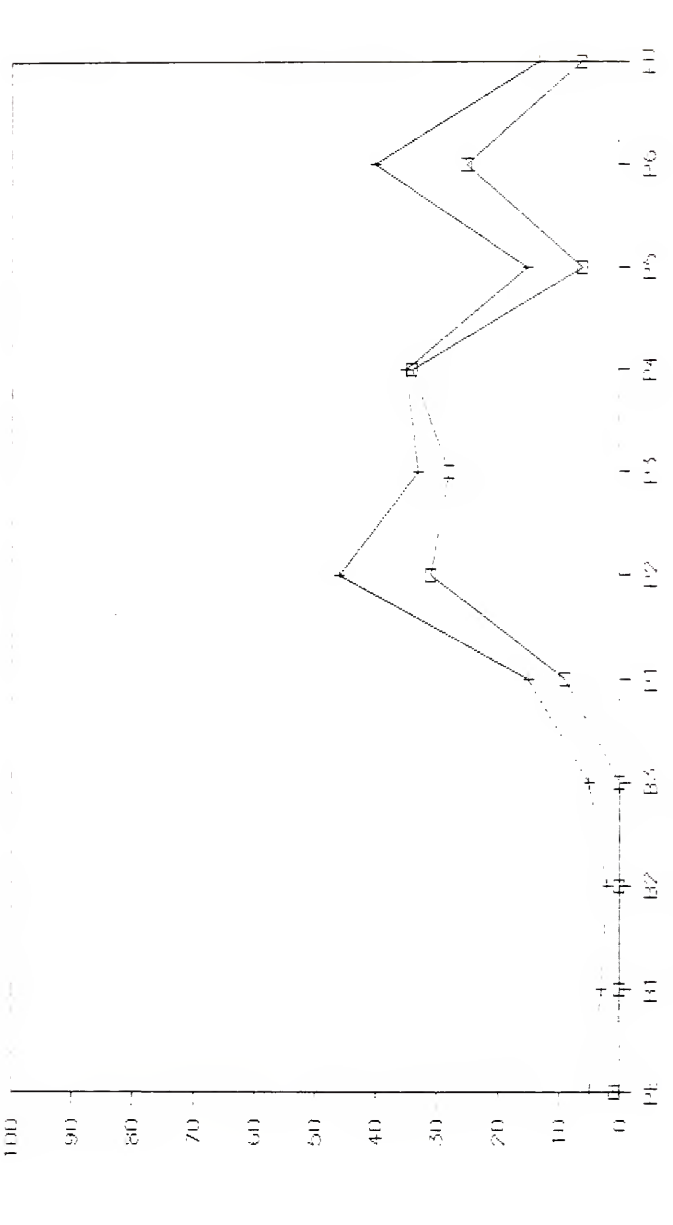

Figure 13. Performance of Subject 4 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

baseline measurements, with only 1% actual cluster production in Baseline 1. The percentage of stridency for those initial consonants that should have been stridents, including /s/ clusters, also remained stable, with 3%, 2%, and 5% evidenced over the three baselines.

Probe measurements

Criterion for termination of training occurred at the sixth training session. Performance on correct cluster production (Figure 11) increased from the baseline levels. Sporadic performance on correct cluster production was observed, with low of 0 at the Probe 5 and a high of 28% at Probe 4. No significant changes were seen in the production of the initial strident singletons across the probes with a range of 5% to 17% (Figure 11). Performance measures for /sp/ and /st/, /sk/, and /br/ during this period are presented in Figure 12. It can be seen that there were no correct productions of the control cluster /br/ over the course of training. There was some change, however, in the target clusters /sp/ and /st/ from 38% correct in Probe 1 to 50% correct by the sixth and final probe. Drops in percentage correct were seen in Probe 3 (25%) and Probe 5 (0). The /s/ plus stop cluster /sk/ evidenced an increase from 0 correct in Probe 1 to 50% correct by Probe 6.

However, the feature of stridency (Figure 13) for those initial consonants that should have been produced as stridents, including consonant clusters, increased from a

baseline of 5% to 46% at Probe 2 and 40% by the sixth and final probe. Overall cluster production (correct or incorrect) was sporadic over the course of training with a high of 34% at Probe 4 and a low of 6% at Probe 5 (Figure 13).

Follow-up phonological evaluation

Test performance. As indicated in Table 40, improvement was noted in the APP--R scores between the pretraining evaluation and the final sample, some two months later. During the initial evaluation, Polly had a phonological deviancy score of 41 compared to a follow-up phonological deviancy score of 39. The former score was in the severe range and the latter in the moderate range.

Consonant sequence reduction remained the highest phonological omission at 80% compared with a pretraining percentage of 85%. No changes were noted in percentage of occurrence for liquid /l/ deficiencies (55%). Stridents, liquid /l/, and liquid /r,ɝ/ remained the most frequently occurring class deficiencies. The percentage of occurrence of liquid /r,ɝ/ deficiencies dropped from 100% to 95%. Additionally, improvements were noted in the strident class, with a change in percentage of occurrence of strident deficiencies from 67% to 53%.

Phonetic inventory. The phonetic inventory for Subject 4 had changed from the pretraining sample to the follow-up sample in the fricative class only. The fricatives /f/ and

/ʃ/ had been added to the inventory with /v/ remaining marginal. All other aspects remained constant. The phonetic inventory at the follow-up evaluation for Subject 4 can be found in Table 47.

Phonetic realizations of consonant singletons. Phonological rules and accompanying examples are presented in Appendix I. Limited changes were noted in Polly's realizations of the fricatives at the follow-up (Table 48). The labial fricative /f/ had the same realization as at the pretraining. The phoneme /v/ continued to be replaced by the voiced labial stop [b] in all positions. The realizations for /s/ and /z/ in the initial and intervocalic positions remained the same as the pretraining sample. Final /s/ and /z/ were produced correctly by the follow-up sample. For the initial palatal fricative /ʃ/, the realization had changed by the addition of /ʤ/ to the follow-up realization, making it [ʃ ~ j ~ ʤ]. Intervocalic /ʃ/ was produced correctly at the follow-up, and no change was evidenced for the realization of final /ʃ/. By the follow-up, /h/ was correctly realized in the initial and intervocalic positions. The realizations of initial /θ/ and /ð/ did not change from the pretraining sample to the follow-up. However, the intervocalic /θ/ was realized as [f] (no examples in this context at the pretraining sample) and final /θ/ as [s ~ p] compared to [f ~ p] at the pretraining evaluation. Intervocalic /ʒ/ was replaced by the stop [d].

Table 47. Follow-up phonetic inventory for Subject 4 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	
Fricative	f (v)		s z	ʃ ʒ		h
Affricate				ʧ ʤ		
Approximant	w		l	j		

Table 48. Summary of follow-up phonetic realizations of the fricatives for Subject 4.

Phoneme	Position		
	Initial	Intervocalic	Final
f	b ~ p	p	p
v	b	b	b
θ	b ~ t	f	s ~ p
ð	d	d	
s	j ~ s ~ sj	s	s
z	j ~ z	j ~ z	z
ʃ	ʃ ~ j ~ ʤ	ʃ	ʃ ~ s
ʒ		ʒ	
h	h	h	

The phonetic realizations of the stops and affricates are summarized in Table 49. The stops /b/, /d/, /k/, and /g/ were produced correctly in all positions as at the pretraining sample. Additionally, /t/ was produced correctly in the initial, intervocalic, and final positions. By the follow-up, the voicing contrast was emerging, with the phoneme /p/ produced correctly in the intervocalic and final position, and realized as [p ~ b] in the initial position. By the follow-up, changes were noted in Polly's realization of the affricates (Table 49). In the initial position, the cognate alveolar stop was added to the realizations for /ʧ/ and /ʤ/. Initial /ʧ/ and /ʤ/ were realized as [t ~ d] at the follow-up, compared with [t] only for /ʧ/, and [d] only for /ʤ/ at the pretraining sample. For the intervocalic positions, the realization of /t/ was [ʔj ~ ʔʃ ~ ʧ ~ t], and the realization of /ʤ/ was [ʒ ~ ʤ]. Final /ʧ/ was realized as [ʔʃ ~ ʧ ~ t] and final /ʤ/ as [ʃ ~ ʤ ~ ʒ]. Thus, Polly's approach to affricate production appeared to be in an active process of reorganization with unclear realizations in the intervocalic and final positions.

The phonetic realizations of the nasals, liquids, and glides are presented in Table 50. The nasals /m/ and /n/ were produced correctly in all positions. The velar /ŋ/ was produced correctly in the intervocalic position compared to the pretraining realization of [k]. Final /ŋ/ was realized as [ŋ ~ ∅] at the follow-up compared to correct production at

Table 49. Summary of follow-up phonetic realizations of the stops and affricates for Subject 4.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p ~ b	p	p
b	b	b	b
t	t	t	t
d	d	d	d
k	k	k	k
g	g	g	g
t	t ~ d	ʔj ~ ʧ ~ ʔʃ ~ t	ʔʃ ~ ʧ ~ t
d	d ~ t	ʒ ~ ʤ	ʃ ~ ʤ ~ ʒ

Table 50. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 4.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		m
n	n	n	n
ŋ		ŋ	ŋ ~ ø
l	l	l	l
r	w	w	
w	w	w	
j	j	j	

the pretraining. Realizations of the liquids and glides were the same as those in the pretraining sample.

Phonetic realizations of consonant clusters. The cluster realizations of Subject 4 at the follow-up are presented in Table 45. By the follow-up evaluation, Polly was producing more correct clusters than at the pretraining (Figure 11). Percentage of correct clusters went from a pretraining level of 1% to 6% at the follow-up. The /s/ plus stop target clusters /sp/ and /st/ (Figure 12) increased in percentage correct by the follow-up. At the pretraining evaluation, no correct /sp/ or /st/ target words were produced compared with 21% correct at the follow-up. The /sk/ cluster (Figure 12) went from 0 correct at the pretraining evaluation to 3% at the follow-up. The control cluster /br/ (Figure 12) was not produced correctly at the follow-up evaluation, but was replaced by the expected stop (just as at the pretraining evaluation). There were no changes in the realizations of /sl/, /sn/, or /sm/ by the follow-up. The one correct /sl/ production evidenced in the pretraining sample was not present in the follow-up sample. Cluster production (either correct or incorrect) had increased from 1% at the pretraining evaluation to 6% at the follow-up (Figure 13). Examples of Polly's cluster attempts are presented in Appendix I.

Homonyms. Subject 4 produced homonyms for 20% of the follow-up sample compared to 26% at the pretraining

evaluation. Intelligibility remained affected by the homonymy, and stopping of fricatives remained an active process.

Phonological knowledge. From the pretraining sample until the follow-up, changes had occurred in the phonological knowledge continuum. A detailed summary can be found in Table 51. The affricates /tʃ/ and /dʒ/ moved from Type 6 to Type 5. The alveolar stop /t/ had changed from Type 4 to Type 1, correct, by the follow-up, as had the nasal /m/. The glide /j/ was realized correctly at the pretraining sample, and was considered Type 1 phonological knowledge. However, by the follow-up sample, this phoneme had changed to Type 4 phonological knowledge.

Performance summary for Subject 4

Subject 4 demonstrated a very slight increase in the production of correct clusters from the pretraining level of 1% to 6% at the follow-up. Polly was producing clusters with 22% accuracy at the sixth and final probe, but this level was not maintained in the period between the final probe and the follow-up testing. The correct production of the trained /sp/ and /st/ clusters was 21% by the final evaluation compared with no correct productions at the pretraining sample. The untrained /sk/ cluster was not produced correctly in the pretraining sample, but the percentage of occurrence by the follow-up was 3%. No significant changes occurred in the correct production of initial strident Table

Table 51. Phonological knowledge continuum for Subject 4 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n b t d k g ʒ h w l
	Type 2	ŋ p j
	Type 3	s z ʃ
	Type 4	
	Type 5	ʧ ʤ
Least Knowledge	Type 6	f v θ ð r

initial strident singletons over the course of the investigation. Finally, the feature of stridency did increase from 5% to 13% by the follow-up, due in part to the increased accuracy of the /s/ plus consonant clusters.

Only slight improvements were noted in the phonological knowledge continuum from the pretraining to follow-up samples. The affricates /ʧ/ and /ʤ/ moved from Type 6 to Type 5 knowledge at the follow-up. The fricatives, with the exception of /ʒ/, did not change in placement on the continuum over the course of the study. A slight improvement in phonological deviancy scores as measured by the APP--R was evidenced. Subject 4 had a phonological deviancy score of 41 at the pretraining evaluation compared with a follow-up score of 39. This improvement changed Polly's severity rating from severe (40-59) to moderate (20-39).

In summary, it appears that the training of /sp/ and /st/ clusters resulted in phonological change in the production of these clusters. However, generalization to untrained clusters was slight, with only 3% of the untrained /sk/ clusters produced correctly. Additionally, the training did not appear to have a significant effect on the generalization of the strident feature.

Subject 5

Background information

Subject 5, Bobby, was aged 4 years, 4 months at the beginning of the study. Developmental history was incomplete

because Bobby had been adopted at age 3 by his present parents. His adoptive mother reported concern about Bobby's speech at the time of the adoption. Bobby was the fourth child in a family of five children, with ages 12, 8, 6, 4, and 2-1/2. He was enrolled in daily preschool at the time of the study.

Test performance. On the PLS, Bobby achieved an auditory comprehension age of 5:0 (years:months) and verbal ability age of 5:3 for an overall language age of 5:1-1/2. On the PPVT--R, Bobby achieved an age equivalency of 5:3. Thus, language skills were within normal limits. Pure tone audiometric screening revealed normal thresholds. Tympanometry indicated normal middle ear functioning. Initial evaluation results are summarized in Table 3.

On the APP--R, Bobby achieved a phonological deviancy score of 45, placing him in the severe range. A detailed summary of the performance of Subject 5 on the APP--R can be found in Table 52. The percentage of occurrence of consonant sequence reduction, including consonant clusters, was 50%, representing the largest percentage in the phonological omission category. Liquid /r,ɝ/, stridents, and liquid /l/ made up the largest percentage of the class deficiencies with 100%, 98%, and 81%, respectively.

Pretraining phonological evaluation

Phonetic inventory. Bobby's pretraining phonetic inventory (Table 53) included the full repertoire of nasals,

Table 52. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 5.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	5	5
Consonant Sequence Reduction	50	45
Consonant Singleton Omissions		
Prevocalic	7	5
Postvocalic	3	6
Class Deficiencies		
Stridents	98	74
Velar Obstruents	36	45
Liquid (l)	81	73
Liquid (r,ɝ)	100	90
Nasals	0	0
Glides	20	20
Total	400	363
Mean	40	36
Age Points (CA of 4:0 = 5)	5	5
Phonological Deviancy Score	45	41
Severity Rating	SEVERE	SEVERE

Table 53. Pretraining phonetic inventory for Subject 5 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v		s z			h
Affricate			ʣ	ʤ		
Approximant	w		l	j		

glides and stops, with the glottal stop /ʔ/ also evidenced. Labial and alveolar fricatives were present, as well as the glottal fricative /h/. The voiced affricates /d͡z/ and /d͡ʒ/ were present in the inventory; however, /t͡ʃ/ was not evidenced. Finally, the liquid /l/ was present in Bobby's inventory, but /r/ was not.

Phonetic realizations of consonant singletons. The singleton realizations of Subject 5 will be described briefly by manner-of-articulation class. Phonological rule statements and accompanying examples are presented in Appendix J. Subject 5 demonstrated a consistent pattern of stopping of fricatives (Table 54). Stops replaced fricatives in all positions with the exception of initial /h/ that was realized as [ø ~ h]. Whereas, some fricatives, /f/, /v/, /s/, and /h/, were occasionally observed in initial position in some examples, intervocalic fricatives were always realized as labial or alveolar stops. The stops were homorganic with the fricatives they replaced and had the same voicing as the target labial and alveolar fricatives. The correct production of /f/ alternated with [p ~ b] in the initial position and with [p] only in the final position. For /v/, the initial and intervocalic realization was [d]. As with final /f/, the correct realization of final /v/ alternated with the homorganic stop [b]. The lingual-dental fricatives were replaced by stops in all examples. The alveolar fricatives /s/ and /z/ were replaced by the expected

Table 54. Summary of pretraining phonetic realizations of the fricatives for Subject 5.

Phoneme	Position		
	Initial	Intervocalic	Final
f	b ~ p ~ f	p	p ~ f
v	b	b	v ~ b
θ	t		p
ð	d	d	
s	t ~ d	t	t
z	d	d	d ~ ø
ʃ	d	d ~ t	d ~ t
ʒ		d	
h	ø ~ h		

homorganic stops in all positions. The stop /d/ alternated with [t] in the initial position for /s/. Additionally, final /z/ was omitted in some examples. The stop /d/ replaced /ʃ/ in all positions; however, for intervocalic and final /ʃ/, the [d] production alternated with [t].

The summary of Bobby's stop and affricate realizations are presented in Table 55. The stops /p/, /b/, and /t/ were realized correctly in all positions, as were /d/ and /g/ in the initial and intervocalic positions. Final /d/ was produced correctly in some examples and omitted in others. The phoneme /k/ alternated with [g] in the initial position for the target /k/, and was replaced by [t] in the intervocalic position. Both final /g/ and /k/ alternated with the alveolar stops /d/ and /t/, with the voicing contrasts maintained. Deaffrication was common in the realizations of /ʧ/ and /ʤ/ (Table 55) in all positions with only two correct productions of /ʤ/ noted across the data sets.

The phonetic realizations of the nasals, liquids, and glides for Subject 5 are presented in Table 56. The labial and alveolar nasals were realized correctly in all positions. There was only one example for the intervocalic /ŋ/, and the realization was [n]. Three forms made up the realization for final /ŋ/, [ŋ ~ n] and omission of the final velar nasal. Gliding was a common process in the realizations of liquid /l/ and /r/ (Table 56) occurring in the initial and

Table 55. Summary of pretraining phonetic realizations of the stops and affricates for Subject 5.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t
d	d	d	d ~ ø
k	k ~ g	t	t ~ k
g	g	g	g ~ d
ʧ	d ~ t	t ~ k	t ~ k
ʤ	d ~ t	d ~ ʤ	d

Table 56. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 5.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	m	m
n	n	n	n
ŋ		n	ŋ ~ n ~ ø
l	w	l ~ w	l ~ ø ~ v
r	w	w	
w	w	w	
j	j	j	

intervocalic positions, with /w/ replacing the liquids. For liquid /l/, there were also some correct productions of the target in the intervocalic and final positions. Final position liquid /l/ was also vowelized or omitted. The glides /w/ and /j/ (Table 56) were realized correctly in the initial and intervocalic positions.

Phonetic realizations of consonant clusters. Bobby's phonetic realizations of the clusters can be found in Table 57. Correct cluster production occurred for only 2% of the pretraining sample. The only clusters Bobby produced for cluster targets in the pretraining sample were [dw] and [tw] for /sl/, and [bw] and [fw] for /br/. The /s/ plus stop clusters were all reduced to the expected stop. Overall cluster production (either correct or incorrect) occurred 29% of the time in the pretraining sample. Examples of Bobby's cluster attempts at the pretraining evaluation can be found in Appendix J.

Homonyms. Subject 5 produced homonyms for 27% of the pretraining sample set. Intelligibility was adversely affected by this homonymy. The phonological process of stopping contributed to this loss of contrasts.

Phonological knowledge. A continuum of phonological knowledge for Subject 5 is presented in Table 58. Phonemes realized correctly in all positions were considered adult-like, and were assigned knowledge Type 1. The Type 1 phonemes from Bobby's sample were /p/, /b/, /m/, /w/, and

Table 57. Cluster realizations for Subject 5 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p	sp ---> p ~ f
st ---> t	st ---> t ~ st
sk ---> k	sk ---> k ~ sk
sl ---> dw ~ tw	sl ---> tw
sn ---> n	sn ---> n ~ sn
sm ---> m	sm ---> m
br ---> bw ~ fw	br ---> fw ~ bw

Table 58. Phonological knowledge continuum for Subject 5 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n p b w j
	Type 2	t d g
	Type 3	k
	Type 4	
	Type 5	ŋ f v h ʤ l
Least Knowledge	Type 6	θ s z ð ʃ ʒ ʧ r

/j/. The stops /t/, /d/, and /g/ were assigned Type 2 phonological knowledge because of the application of optional rules. The velar stop /k/ was assigned Type 3 phonological knowledge, with some correct productions in all positions, but not for all morphemes. The Type 5 phonemes were those that had correct productions in at least one position, but not for all morphemes. Bobby's Type 5 phonemes were /f/, /v/, /h/, /ʤ/, /ŋ/, and /l/. Finally, those phonemes not in Bobby's phonetic inventory, i.e., /s/, /z/, /ʃ/, /ʒ/, /θ/, /ð/, /ʧ/, and /r/, were considered Type 6, non-adult-like.

Baseline measurements

Bobby's performance across time beginning with the pretraining evaluation, and including the baseline measurements, the probe measurements, and the follow-up evaluation, is illustrated in Figures 14, 15, and 16. For Subject 5, nine baseline measurements were made prior to the initiation of training. Performance remained stable for all baseline measures, with only 1% correct cluster production noted in Baseline 1 (Figure 14). The percentage of initial strident singletons (Figure 14) produced correctly did not fluctuate significantly with the range from 1% to 10% observed across the baselines. No /s/ plus stop clusters or control clusters, (br), were produced correctly during any of the measurements (Figure 14). Finally, percentages for overall cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed

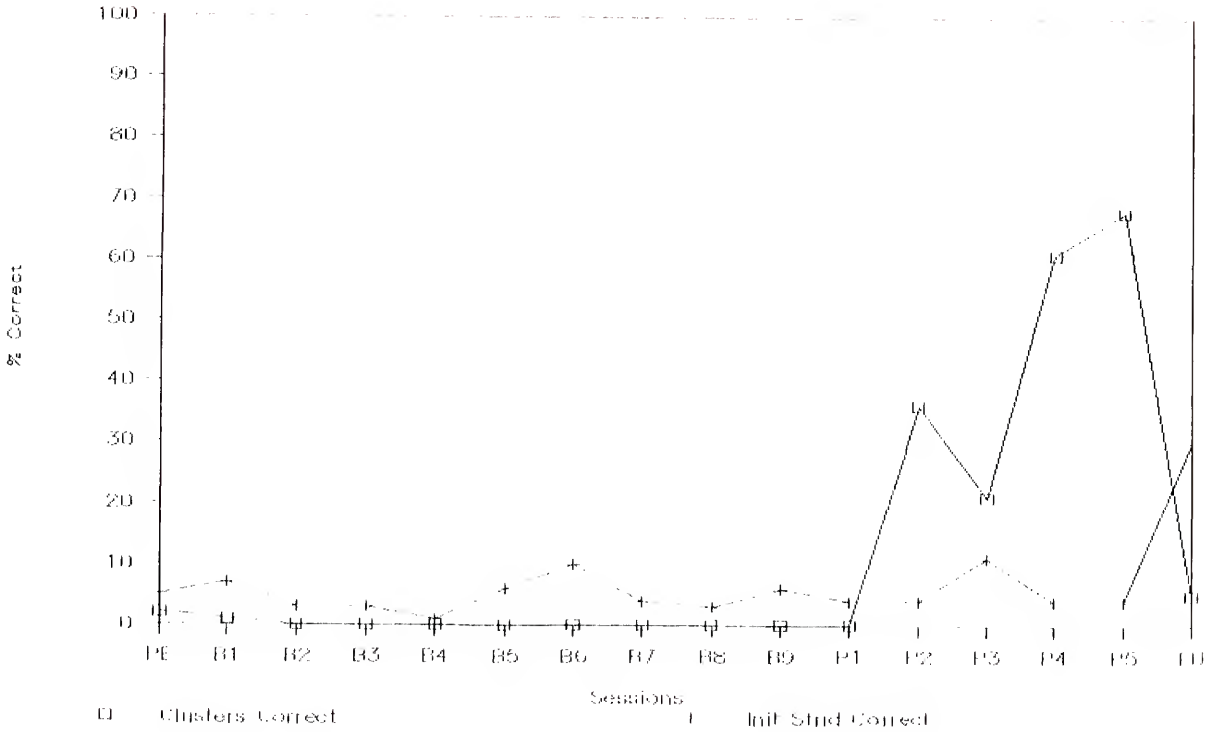

Figure 14. Performance of Subject 5 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

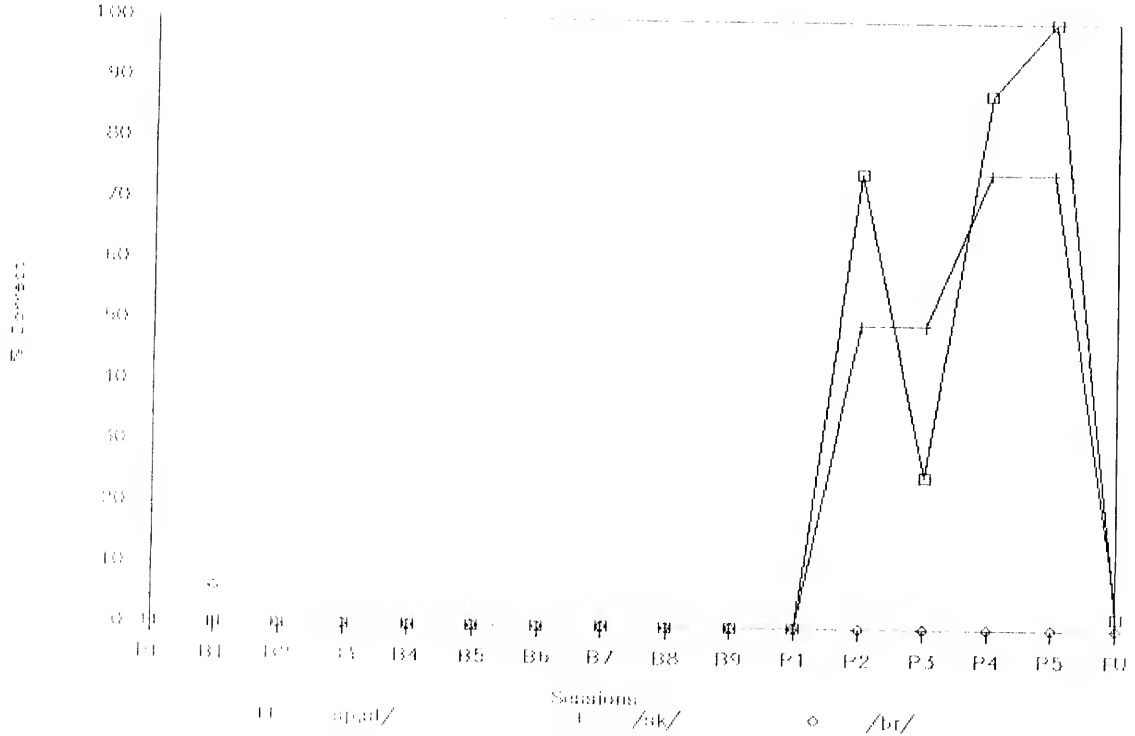

Figure 15. Performance of Subject 5 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

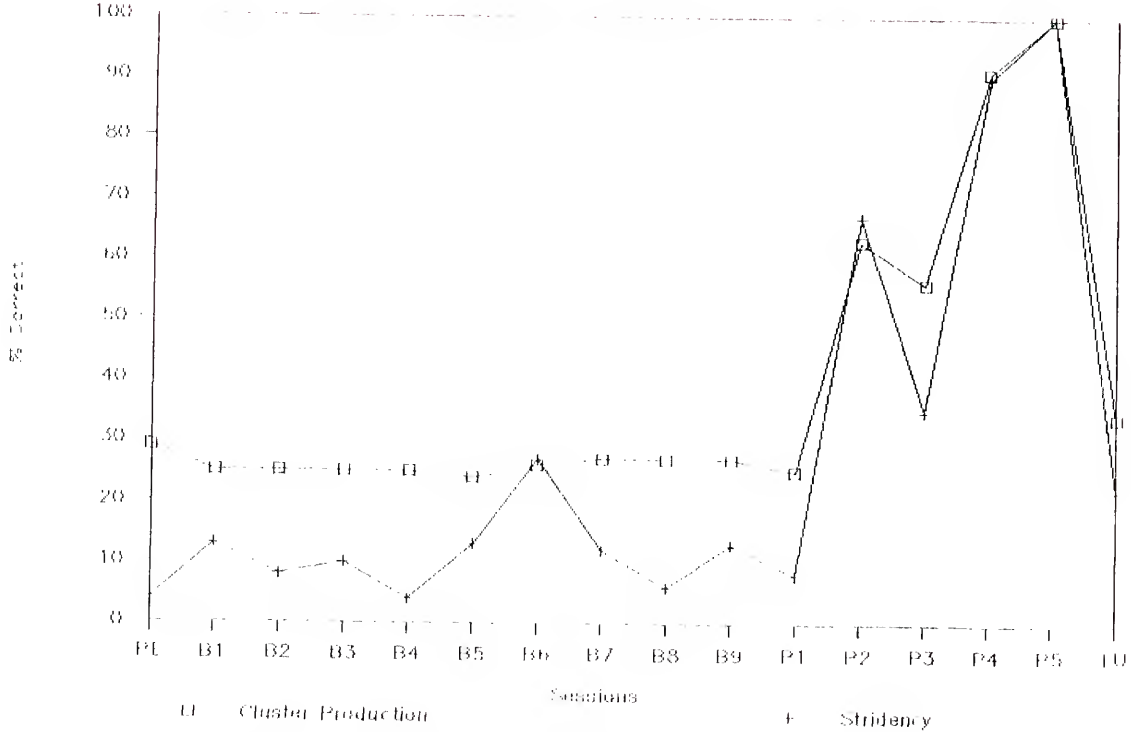

Figure 16. Performance of Subject 5 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

and are presented in Figure 16. The percentage of occurrence for cluster productions (either correct or incorrect) remained stable with a range of 24% to 27%. Production of strident phonemes did not follow a consistent pattern with a low of 4% evidenced at Baseline 4 and a high of 27% at Baseline 6.

Probe measurements

Criterion for termination of the training of /sp/ and /st/ clusters was reached at the fifth training session. Correct cluster production (Figure 15) steadily increased from a low of 0 at Probe 1 to a high of 68% by the fifth and final probe. No significant changes can be seen in the production of correct strident singletons (Figure 15). The range was 3% to 11% across the probes. Performance measures for the clusters /sp/ and /st/, /sk/, and /br/ during this period are presented in Figure 14. It can be seen that there were no correct productions of the control cluster /br/ over the course of training. There was some change, however, in the target clusters /sp/ and /st/ from no correct productions in Probe 1 to 100% correct by the fifth and final probe. A temporary drop occurred during Probe 3 from 75% correct in Probe 2 to 25% correct in the third probe. Steady increases in correct production of the /sk/ cluster can be seen from Probe 1 to Probe 5 with a final correct production of 75% in Probe 5.

The percentage of stridency (Figure 16) for those initial consonants that should have been produced as

stridents, including /s/ clusters, increased from 8% at Probe 1 to 100% by Probe 6. An interesting increase in actual cluster production occurred during the course of training and is presented in Figure 16. There was an increase from an initial cluster occurrence of 25% in Probe 1 to a 100% cluster occurrence in Probe 5.

Follow-up phonological evaluation

Test performance. As indicated in Table 52, slight improvement was noted in the APP--R scores between the pretraining evaluation and the final administration, some two months later. During the initial evaluation, Bobby had a phonological deviancy score of 45 compared to a final phonological deviancy score of 41. Both scores are within the severe range.

Consonant sequence reduction remained the highest phonological omission at 45% compared with a pretraining percentage of 50. Improvements were noted in liquid /r,ɝ/, with a change in percentage of occurrence of liquid /r,ɝ/ deficiencies from 100% to 90%. Liquid /r,ɝ/, stridents, and liquid /l/ remained the most frequently occurring class deficiencies. Improvements were noted in the strident class, with a change from 98% to 74%. Additionally, percentage of occurrence of liquid /l/ deficiencies dropped from 81% to 73%.

Phonetic inventory. The phonetic inventory (Table 59) for Subject 5 had changed from the pretraining sample to the

Table 59. Follow-up phonetic inventory for Subject 5 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v	(θ)	s z	(ʃ)	(x)	h
Affricate				ʧ ʤ		
Approximant	w		l	j		

follow-up sample in several ways. The fricatives /θ/, /ʃ/, and /x/ had been added as marginal phones. Whereas the affricate /ʤ/ was not present in the follow-up inventory, the standard English affricate /ʧ/ appeared. All other aspects remained constant.

Phonetic realizations of consonant singletons. Phonological rule statements and accompanying examples are presented in Appendix J. Subject 5 appeared to be in the process of altering his realization of fricatives by the follow-up evaluation (Table 60). The emergence of stridency was evidenced in the follow-up realizations of /f/ and /v/. The initial /f/ realization was [f ~ p], and the realization of intervocalic /f/ had expanded to [f ~ v ~ p]. Final /f/ maintained the same realization. The /v/ phoneme was produced correctly in all positions at the time of the follow-up. The lingual-dental fricative /θ/ had the same realization in the initial position, [t], as at the pretraining. Final /θ/ changed from the stop [p] to [f ~ t] at the follow-up, and intervocalic /θ/ was replaced by [f]. No changes were noted in the realizations of initial and intervocalic /ð/ with both replaced by the stop [d]. Additionally, the feature of stridency appeared to be emerging in Bobby's realization of /ʃ/. The cluster [st] was produced for /ʃ/ in the initial position along with [t ~ d]. Intervocalic /ʃ/ was replaced by [ʧ], [ʤ], or [d], and final /ʃ/ was replaced by [d] only. No change was noted in

Table 60. Summary of follow-up phonetic realizations of the fricatives for Subject 5.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f ~ b	f ~ p ~ v	f ~ p
v	v	v	v
θ	t	f	f ~ t
ð	d	d	
s	d ~ t	t	t
z	d	d	ø ~ d
ʃ	t ~ d ~ st	d ~ ʧ ~ ʤ	d
ʒ		d	
h	h ~ ø		

the realization of intervocalic /ʒ/ (replaced by [d]), or initial /h/ (realized as [h ~ ∅]).

By the follow-up evaluation, much change had occurred in the realizations of the stop phonemes (Table 61). At the pretraining evaluation, /p/, /b/, and /t/ were realized correctly in all positions. However, by the follow-up sample, some additional phonemes emerged in the realizations. The /p/ phoneme was realized as [p ~ f] in all positions. Initial and intervocalic /b/ were produced correctly, however, word final /b/ had no clear realization, with six different variations evidenced. Of these six different variations, only two occurred more than once. Although /t/ was produced correctly in the initial and final positions, the correct production alternated with [d] in the intervocalic position. Final /d/ was realized as [d ~ n ~ ∅], whereas initial and intervocalic /d/ were produced correctly. The velar stops, /k/ and /g/ were produced correctly in the initial positions. However, the intervocalic /k/ was replaced by [t], and final [k] was realized as [t ~ k ~ d]. Intervocalic and final /g/ were replaced by the alveolar stop [d].

The realizations of the affricates (Table 61) had changed from the pretraining sample by the addition of phonemes. Examples of /ʧ/ and /ʤ/ replaced by alveolar stops occurred in all positions. The realizations of initial /ʧ/ and /ʤ/ remained the same as at the pretraining sample.

Table 61. Summary of follow-up phonetic realizations of the stops and affricates for Subject 5.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p ~ f	p ~ f	p ~ f
b	b	b	b ~ v ~ m ~ n ~ d ~ ø
t	t	t ~ d	t
d	d	d	d ~ n ~ ø
k	k	t	t ~ k ~ d
g	g	d	d
ʧ	t ~ d	t ~ ʧ	t
ʤ	d ~ t	d ~ t ~ v	d ~ t ~ ø

The affricate /ʧ/ emerged in the intervocalic position, although it alternated with [t]. Final /ʧ/ had changed from a realization of [t ~ k] to [t] only. At the follow-up, the correct production of /ʤ/ was no longer evidenced, with the pretraining realization of [d ~ ʤ] changed to [d ~ t ~ v]. Final /ʤ/ changed from [d] only to the alternation of [d] and [t], with some examples of the target also omitted.

The phonetic realizations of the nasals, liquids, and glides are presented in Table 62. The realizations of all nasals remained the same as those in the pretraining sample with the exception of final /ŋ/. Final /ŋ/ was produced correctly at the follow-up. The liquids and glides remained the same from the pretraining to the follow-up evaluation (Table 62).

Phonetic realizations of consonant clusters. Bobby's phonetic realizations of the clusters at the follow-up are presented in Table 57. By the follow-up evaluation, Subject 5 was producing slightly more correct clusters than at the pretraining. Percentage of correct clusters (Figure 14) went from a pretraining level of 2% to 5% at the follow-up. Performance on the clusters /sp/ and /st/, /sk/, and /br/ can be found in Figure 15. Some stridency was added to the realization of /sp/ in the form of [f]. This production could be considered a coalescence of the stridency feature of /s/ and the labial place feature of /p/. The /st/ cluster was realized correctly in some examples, and as [t] in

Table 62. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 5.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		m
n	n	n	n
ŋ		n	ŋ
l	w	l ~ w	l ~ ø ~ v
r	w	w	
w	w	w	
j	j	j	

others. Only 2% of the target clusters /sp/ and /st/ were produced correctly (Figure 15). There was one example of /sk/ realized correctly, with the remainder realized as /k/. At the time of the pretraining evaluation, there was one correct production of /br/. By the follow-up, no correct realizations were evidenced (Figure 15). The cluster /sl/ changed from a realization of [dw ~ tw] to [tw] only. The /s/ plus nasal clusters remained essentially the same across evaluations, with the exception of one correct production of /sn/ at the follow-up evaluation. Percentage of overall cluster occurrence (either correct or incorrect) was 34%, up slightly from the pretraining level of 29%. Examples of Bobby's cluster attempts at the follow-up can be found in Appendix J.

Homonyms. Subject 5 produced homonyms for 23% of the follow-up sample compared with 27% at the pretraining evaluation. Intelligibility remained affected, and stopping of fricatives remained an active process for Subject 5.

Phonological knowledge. From the pretraining sample until the follow-up evaluation, considerable change had occurred in the phonological continuum (Table 63). The fricative /v/ changed from Type 5 to Type 1, correct and adult-like. The voiceless cognate /f/ moved from Type 5 to Type 3 at the follow-up. The phonemes, /ŋ/ and /l/, changed from Type 5 to Type 4. The affricate /ʧ/, not present in the pretraining inventory, was assigned Type 5

Table 63. Phonological knowledge continuum for Subject 5 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n v w j
	Type 2	t d
	Type 3	p b k f
	Type 4	ŋ g l
	Type 5	h ʧ ʤ
Least Knowledge	Type 6	θ s ð ʃ ʒ r

knowledge at the follow-up. Finally, three phonemes changed in the phonological assignment with movement toward the least-knowledge end of the continuum. The stops /p/ and /b/ moved from Type 1, correct, adult-like, to Type 3 knowledge. Also, the stop /g/ changed from Type 2 to Type 4 knowledge by the follow-up.

Performance summary for Subject 5

Subject 5 was producing slightly more correct clusters by the follow-up sample, 5% compared to a pretraining level of 2%. Additionally, the occurrence of actual cluster productions (either correct or incorrect) also increased from 29% to 34% by the follow-up evaluation. The changes in the trained /sp/ and /st/ clusters were negligible, with no correct productions in the pretraining sample and only 2% produced correctly at the follow-up. The untrained /sk/ cluster had a higher proportion of correct productions by the follow-up, with 4% present compared to 0 at the pretraining sample. The correct production of initial strident singletons increased from 5% to 30%, and the feature of stridency (including clusters) increased from 4% to 22%.

Bobby's speech samples were different from the pretraining evaluation to the follow-up. Some reorganization or change was evidenced in the addition of phonemes and marginal phonemes to the final phonetic inventory. Changes occurred in fricative productions over time, with the emergence of /f/ in the intervocalic position. The phoneme

/v/ had emerged completely by the time of the follow-up evaluation. The alveolar fricatives /s/ and /z/ underwent considerable change. It appeared that Subject 5 was in a process of experimentation with these phonemes, as evidenced by the final consonant realizations that included six different realizations for /s/ and five for /z/.

Slight changes in the phonological continuum were observed for the fricatives /f/ and /v/, and the affricate /ʧ/. The /v/ phoneme moved from Type 5 to Type 1 knowledge; /f/ moved from Type 5 to Type 3; and /ʧ/ moved from Type 6 to Type 5. Other changes involved movement toward the least-knowledge end of the continuum for /p/, /b/, and /g/.

Subject 5 remained in the severe category for both administrations of the APP--R, with a pretraining phonological deviancy score of 45 compared with a follow-up score of 41. Consonant sequence reduction remained the most frequently occurring phonological omission. It would appear that Bobby's phonological system was in the process of reorganization by the follow-up sample. It is questionable, however, that the training on the /s/ plus stop target clusters had any significant effect on the child's overall system.

Subject 6

Background information

Subject 6, John, was aged 4 years, 6 months at the beginning of the study. He was the product of an

unremarkable pregnancy, and all developmental milestones were within the normal range. John is the youngest of two children, with a brother three years older. John's brother was reported to have had a speech problem that was resolved with no intervention. At the time of the study, John was enrolled in a daily preschool program.

Test performance

On the PLS, John achieved an auditory comprehension age of 5:9 (years:months) and verbal ability age of 6:1-1/2 for an overall language age of 5:1-1/2. On the PPVT--R, John achieved an age equivalency of 5:5. Thus, language skills were above his chronological age. Pure tone audiometric screening revealed normal thresholds, and tympanometry indicated normal middle ear functioning. Initial evaluation results are summarized in Table 3.

On the APP--R, John achieved a phonological deviancy score of 55, placing him in the severe range. A detailed summary of the pretraining performance of Subject 6 on the APP--R can be found in Table 64. The percentage of occurrence of consonant sequence reduction, including consonant clusters, was 125%, representing the largest percentage in the phonological omission category. A percentage of occurrence above 100% is possible because the test instrument is based on the reduction of consonant sequences to one element (Hodson, 1986). In John's case, entire consonant sequences were omitted. Stridents, liquid /r,ɝ/, liquid /l/,

Table 64. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 6.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	0	0
Consonant Sequence Reduction	125	65
Consonant Singleton Omissions		
Prevocalic	25	16
Postvocalic	26	23
Class Deficiencies		
Stridents	79	62
Velar Obstruents	14	9
Liquid (l)	82	27
Liquid (r,ɝ)	86	86
Nasals	11	11
Glides	50	20
Total	498	288
Mean	50	29
Age Points (CA of 4:0 = 5)	5	5
Phonological Deviancy Score	55	34
Severity Rating	SEVERE	MODERATE

and glides made up the largest percentage of the class deficiencies with 79%, 86%, 82%, and 50%, respectively.

Initial phonological evaluation

Phonetic inventory. John's pretraining phonetic inventory (Table 65) included the full complement of nasals, stops, affricates, and glides. All fricatives were present, with the exceptions of the lingual-dental fricatives /θ/ and /ð/, with /ð/ being marginal, and /θ/ absent from the inventory.

Phonetic realizations of singleton consonants. The singleton realizations of Subject 6 will be described briefly by manner-of-articulation class. Phonological rule statements and accompanying examples are presented in Appendix K. Subject 6 evidenced patterns of omission and glottal replacement in his production of fricatives (Table 66). The labial fricatives /f/ and /v/ were produced correctly in all positions. However, initial /v/ was omitted in some examples. The realizations of the alveolar fricatives were unclear. Initial /s/ was realized as [ø ~ ʃ ~ ʒ ~ s], with intervocalic and final /s/ realized as [ʔ ~ ø ~ ʃ]. The replacement of /s/ with [ʃ] occurred in a morpheme-specific context, with the words icy and ice produced as [a͡ɪʃɪ] and [a͡ɪʃ], respectively. The final /z/ realization paralleled that of the final /s/ with the realization of [ø ~ ʔ ~ z]. Initial /z/ was realized as [ʒ ~ ʤ ~ ø ~ z], and intervocalic /z/ was omitted in all target words. Omission

Table 65. Pretraining phonetic inventory for Subject 6 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v	(θ)	s z	ʃ ʒ		h
Affricate				ʧ ʤ		
Approximant	w		l	j (r)		

Table 66. Summary of pretraining phonetic realizations of the fricatives for Subject 6.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f	f	f
v	v ~ ø	v	v
θ	ø		ø ~ ʔ
ð	d ~ ø		
s	ø ~ ʃ ~ ʒ ~ s	ʔ ~ ø ~ ʃ	ʔ ~ ø ~ ʃ
z	ʒ ~ ʤ ~ ø ~ z	ø	ø ~ ʔ ~ z
ʃ	ʃ ~ ø	ʔ ~ ø	ʔ ~ ø
ʒ		ʔ	
h	h		

of the palatal /ʃ/ was evidenced in all positions. However, some examples containing initial /ʃ/ were produced correctly, and some examples containing intervocalic and final /ʃ/ were replaced by [ʔ]. The glottal fricative /h/ was realized correctly in the initial position. Initial and intervocalic /θ/ were omitted, and examples of /θ/ replaced by [ʔ] were evidenced in the intervocalic position. For /ð/, the initial position was realized as [d~ Ø], and intervocalic /ð/ was replaced by the glottal stop /ʔ/.

The phonetic realizations of the stops and affricates are presented in Table 67. The stops /p/, /b/, /k/, and /g/ were produced correctly in all positions, as were /t/ and /d/ in the initial and intervocalic positions. In the final position, /t/ and /d/ were produced correctly in some examples but were omitted in others. Additionally, final /t/ alternated with [ʔ]. As with the fricatives, glottal replacement and consonant omissions were active in John's affricate realizations (Table 67). These realizations were unclear. Initial /ʧ/ had four different representations, [ʃ~ ʧ ~ t ~Ø], with intervocalic /ʧ/ realized as [ʔ~ʃ], and final /ʧ/ as [Ø~ ʔ~ʃ]. Initial /ʤ/ was realized as [ʤ~ ʃ~ d], and intervocalic and final /ʤ/ as [ʔ~ Ø].

A summary of John's phonetic realizations of the nasals, liquids, and glides at the pretraining evaluation are presented in Table 68. For Subject 6, the labial and alveolar nasals were produced correctly in all positions.

Table 67. Summary of pretraining phonetic realizations of the stops and affricates for Subject 6.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t ~ ʔ ~ ø
d	d	d	d ~ ø
k	k	k	k
g	g	g	g
ʧ	ʃ ~ ʧ ~ t ~ ø	ʔ ~ ʃ	ø ~ ʔ ~ ʃ
ʤ	ʤ ~ ʃ ~ d	ʔ ~ ø	ʔ ~ ø

Table 68. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 6.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		m
n	n	n	n
ŋ		ŋ	ŋ ~ n
l	l	l	l ~ v ~ ø
r	w	w	
w	w	w	
j	j	j	

The intervocalic and final /ŋ/ were produced correctly, although final /ŋ/ also alternated with [n]. The liquid /l/ was produced correctly in the initial and intervocalic positions. In the final position, the target was produced correctly, vowelized or omitted. The liquid /r/ was replaced by the glide [w] in the initial and intervocalic positions. The glides /w/ and /j/ were produced correctly in the initial and intervocalic positions (Table 68).

Phonetic realizations of consonant clusters. Cluster production was infrequent in John's pretraining sample. The cluster realizations at the pretraining sample are presented in Table 69. One correct production of /sp/ was evidenced, and [fw] and [bw] were produced for the control cluster /br/. The /s/ plus stop clusters were reduced to the expected stops. The control cluster /br/ was realized as [Ø ~ f ~ b ~ fw ~ bw]. The /sl/ cluster was realized as [Ø ~ f]. The /s/ plus nasal clusters /sn/ and /sm/ were realized as [Ø ~ ʃ] and [Ø ~ f ~ m], respectively. Examples of John's cluster attempts can be found in Appendix K.

Homonyms. Subject 6 produced homonyms for 17% of the pretraining sample set. Intelligibility was moderately affected by the loss of contrasts. The processes of omission and glottal replacement attributed to the homonymy.

Phonological knowledge. A continuum of phonological knowledge for Subject 6 is presented in Table 70. Phonemes realized correctly in all positions were considered adult-

Table 69. Cluster realizations for Subject 6 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p ~ sp	sp ---> p
st ---> t	st ---> t
sk ---> k	sk ---> k
sl ---> ø ~ f ~ s	sl ---> ø ~ s
sn ---> ø ~ ʃ	sn ---> ø
sm ---> ø ~ f ~ m	sm ---> ø
br ---> ø ~ f ~ b ~ fw ~ bw	br ---> bw ~ b

Table 70. Phonological knowledge continuum for Subject 6 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n p b k g h w j
	Type 2	ŋ d v l
	Type 3	t
	Type 4	
	Type 5	s ʃ ʧ ʤ
Least Knowledge	Type 6	f θ ð z ʒ r

like, and were assigned knowledge Type 1. The Type 1 phonemes from John's sample were /h/, /p/, /b/, /k/, /g/, /m/, /n/, /w/, and /j/. Because of the application of optional rules, /v/, /d/, /ŋ/, and /l/ were assigned Type 2 phonological knowledge. The stop /t/ was assigned Type 3 knowledge, characterized by some productions correct in all positions, but not for all morphemes. The fricatives /s/ and /ʃ/ and the affricates /ʧ/ and /ʤ/ were assigned Type 5 phonological knowledge. These targets were produced correctly in at least one position, but not for all morphemes. Finally, the phonemes not in John's inventory, i.e., /f/, /z/, /ʒ/, /θ/, /ð/, and /r/, were considered Type 6 or non-adult-like.

Baseline measurements

John's performance across time, beginning with the pretraining evaluation through the follow-up sample, is illustrated in Figures 17, 18, and 19. Eleven baseline measures were made prior to initiation of training for Subject 6. Performance remained stable for all baseline measures. During the baseline, correct cluster production (Figure 17) was evidenced in Baseline 1 only, with 1% occurrence. The percentage of initial strident singletons produced correctly did not increase significantly, with the range from 50% to 64% observed across the baselines. One correct /sp/ production was evidenced in Baseline 1. Thereafter, no /s/ plus stop clusters (Figure 18) were produced

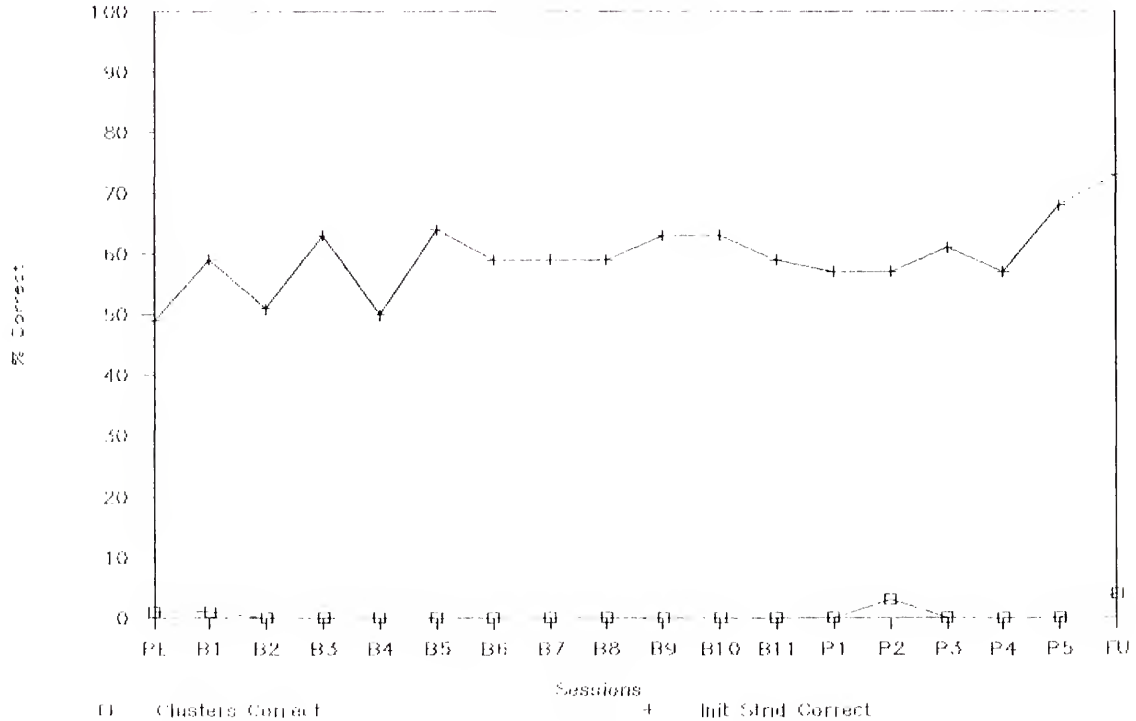

Figure 17. Performance of Subject 6 on correct cluster production and correct initial strident singletons at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

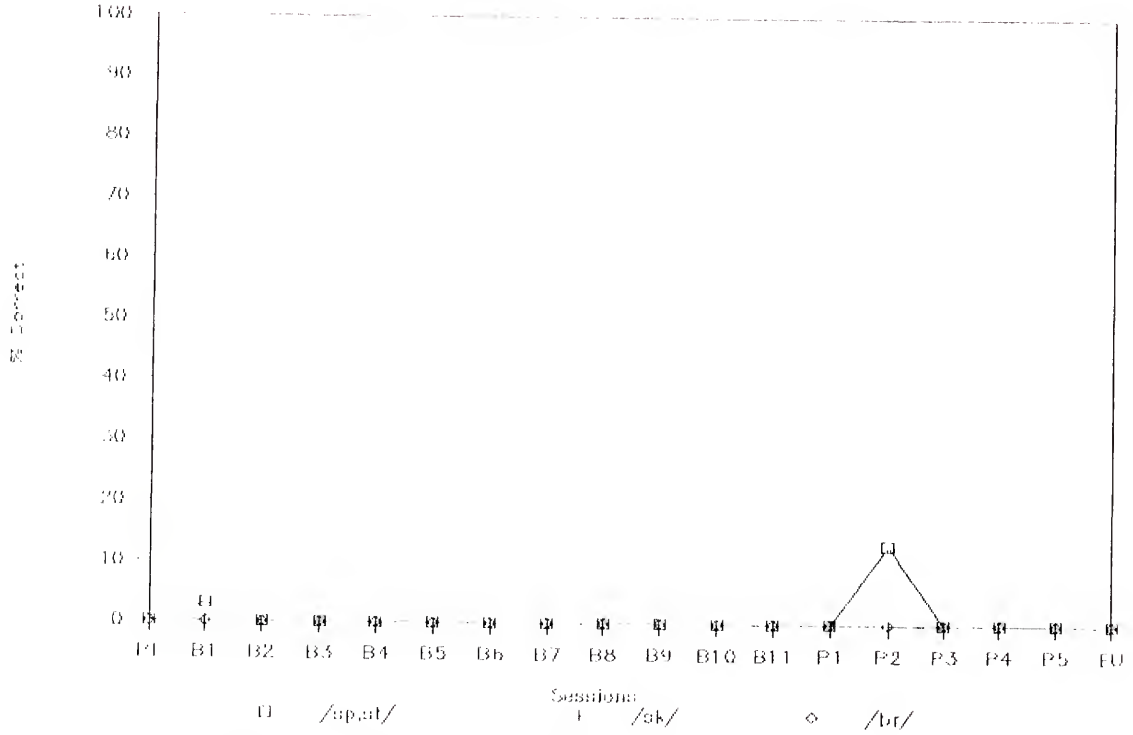

Figure 18. Performance of Subject 6 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

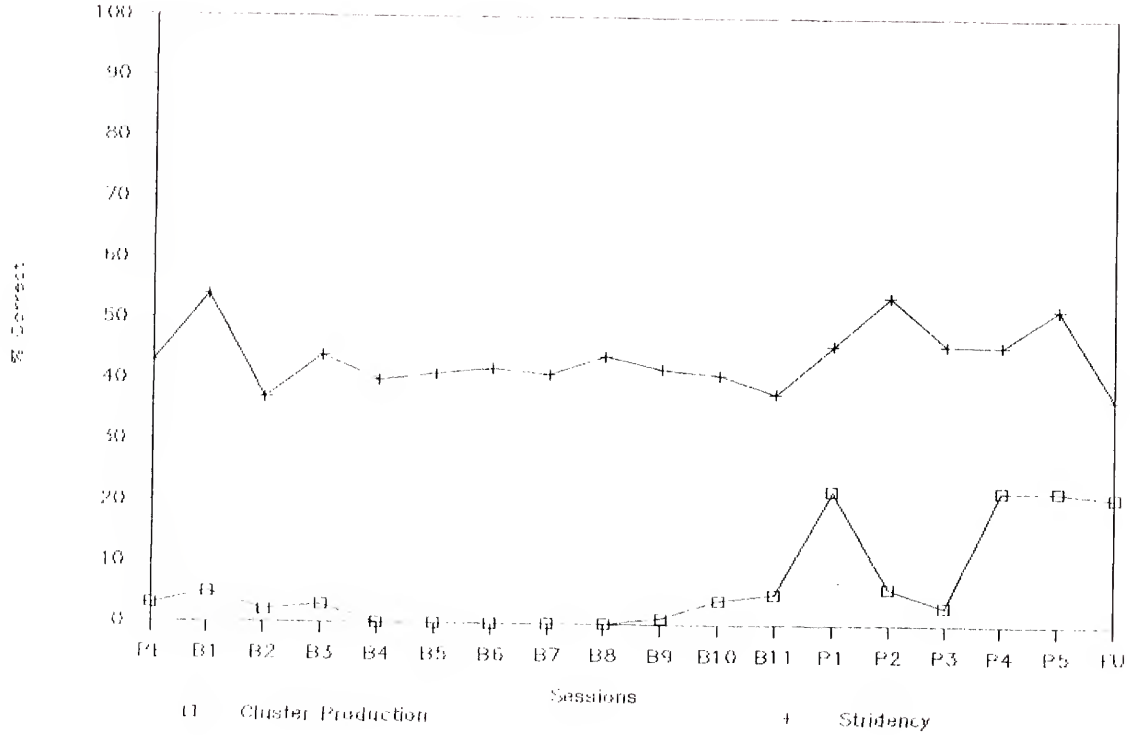

Figure 19. Performance of Subject 6 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ plus stop clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P), and the follow-up evaluation (FU).

correctly. There were no instances of correct production of the control cluster /br/ (Figure 18).

Finally, percentages for overall consonant cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed and are presented in Figure 19. Overall cluster production remained stable with a high of 5% evidenced at Baselines 1 and 11. The percentage of stridency for those initial consonants that should have been produced as stridents, including /s/ clusters, also remained stable.

Probe measurements

Criterion for termination of training of the /sp/ and /st/ clusters occurred at the fifth training session. No significant changes in correct cluster production (Figure 17) were observed over the course of the generalization measures, with 3% correct observed at Probe 2. Additionally, the correct production of initial strident singletons (Figure 17) did not change significantly. Performance measures for the clusters /sp/ and /st/, /sk/, and /br/ during this period are presented in Figure 18. There were no correct productions of the control cluster /br/ or the untrained cluster /sk/ over the course of training. No significant change occurred in the productions of the /s/ plus stop cluster targets /sp/ and /st/, with the only correct productions occurring in Probe 2 (13%). However, the feature of stridency (Figure 19), including /s/ clusters, did show increases during the probe

measurements with a final level of 68% at Probe 5. Overall cluster production (Figure 19) also increased from the baseline levels with 22% occurrence by Probe 5.

Follow-up phonological evaluation

Test performance. As indicated in Table 64, improvements were noted in the APP--R scores from the pretraining evaluation until the final administration, some two months later. During the initial evaluation, John had a phonological deviancy score of 55 compared to a follow-up phonological deviancy score of 37. The former score was within the severe range (40-59) and the latter in the moderate range (20-39).

Consonant sequence reduction remained the highest phonological omission at 65%, compared to a pretraining percentage of 125%. Glide deficiencies improved from 50% to 20% at the follow-up. Stridents, liquid /l/, and liquid /r,ɝ/ remained the most frequently occurring class deficiencies. However, improvements were noted, with strident deficiencies dropping from 79% to 62%, and liquid /l/ dropping from 82% to 27%. The percentage of occurrence for liquid /r,ɝ/ deficiencies remained the same at 86%.

Phonetic inventory. One change in the fricative class was noted in John's phonetic inventory (Table 71) at the time of the follow-up sample. The phoneme /ð/ was present in the inventory, changing from its earlier marginal form. All other aspects remained the same.

Table 71. Follow-up phonetic inventory for Subject 6 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f v	ð	s z	ʃ ʒ		h
Affricate				ʧ ʤ		
Approximant	w		l	j		

Phonetic realizations of singleton consonants. Phonological rule statements and accompanying examples are presented in Appendix K. Examples are included only for the realizations that differ from the adult model. By the follow-up evaluation, an increase in the feature of stridency was noted for the fricatives (Table 72). The labial fricatives /f/ and /v/ were produced correctly in all positions by the follow-up. The fricative /θ/ was omitted in the initial and final positions, and did not occur in the data set in the intervocalic position. The phoneme /ð/ was realized as [d∼ð] in the initial position, and was replaced by the glottal stop in the intervocalic position. Initial /s/ was omitted, with intervocalic /s/ either omitted or replaced by the glottal stop at the follow-up. Final /s/ was either produced correctly, omitted, or replaced by the glottal stop. For /z/, the initial realization was [ø∼ʤ∼ʒ]. Intervocalic /z/ continued to be omitted, and final /z/ was either produced correctly or omitted. The affricate /ʧ/ was introduced to the realization of the palatal fricative /ʃ/, with [ʃ∼ʧ] produced in all positions; however /ʃ/ alternated with [ʔ] and [ʧ] in the final position. The phoneme /h/ was produced correctly in the initial position.

The phonetic realizations of the stops and affricates are presented in Table 73. The stops were produced correctly in all three positions. Omission, deaffrication, and glottal

Table 72. Summary of follow-up phonetic realizations of the fricatives for Subject 6.

Phoneme	Position		
	Initial	Intervocalic	Final
f	f	f	f
v	v	v	v
θ	ø		ø
ð	d ~ ð	ʔ	
s	ø	ʔ ~ ø	ʔ ~ s ~ ø
z	ø ~ ʤ ~ ʒ	ø	ø ~ z
ʃ	ʃ ~ ʧ	ʃ ~ ʧ	ʃ ~ ʔ ~ ʧ
ʒ		ʤ	
h	h		

Table 73. Summary of follow-up phonetic realizations of the stops and affricates for Subject 6.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p
b	b	b	b
t	t	t	t
d	d	d	d
k	k	k	k
g	g	g	g
ʧ	ʧ	ʧ	ʧ
ʤ	ʤ	ʤ ~ ʒ	ʤ ~ ʧ

replacement observed in the pretraining realizations of the affricates were absent from the follow-up (Table 73). The affricate /ʧ/ was produced correctly in all positions. The voiced cognate /ʤ/ was produced correctly in all positions, although /ʤ/ alternated with /ʒ/ intervocalically and with /ʧ/ finally.

John's phonetic realizations of the nasals, liquids, and glides are presented in Table 74. By the follow-up, the nasals were correctly realized in all positions. Liquid /l/ showed no change in the initial and intervocalic positions, with correct productions observed in these positions. However, the realization in the final position changed from [l ~ ø ~ V] to [l ~ V] only. There was no change in liquid /r/ from the pretraining sample to the follow-up. Realizations of the glides (Table 74) were the same as that of the pretraining sample.

Phonological realizations of consonant clusters. By the follow-up evaluation, the greatest change was a collapse of the number of different phonemes included in the realizations. A summary of cluster realizations at the follow-up evaluation can be found in Table 69. Percentage of correct clusters (Figure 17) went from a pretraining level of 1% to 4% at the follow-up. The /s/ plus stop clusters (Figure 18) were replaced by the expected stops. No correct productions of these targets were observed. The control cluster /br/ was replaced by the expected stop or the cluster [bw] with no

Table 74. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 6.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m		m
n	n	n	n
ŋ		ŋ	ŋ
l	l	l	l ~ V
r	w	w	
w	w	w	
j	j	j	

correct productions evidenced. The /sl/ cluster was either reduced to the fricative [s] or omitted completely. Additionally, the /s/ plus nasal clusters were completely omitted by the follow-up sample. The percentage of overall cluster production (either correct or incorrect) changed from a pretraining level of 3% to 21% by the follow-up sample (Figure 19). Examples of John's cluster attempts can be found in Appendix K.

Homonyms. Subject 6 produced homonyms for 13% of the follow-up sample compared with 17% at the pretraining evaluation. Intelligibility remained significantly affected. The process of consonant sequence omission contributed to the loss of contrasts.

Phonological knowledge. Positive changes had occurred in the phonological knowledge continuum from the pretraining sample until the follow-up evaluation for Subject 6. A detailed summary can be found in Table 75. The fricative /f/ moved from Type 6 phonological knowledge to Type 1, correct adult-like, and /v/ moved from Type 2 to Type 1. The phoneme /ʃ/ moved from Type 5 to Type 3, with some correct productions in all positions, but not for all morphemes. All stops were Type 1 by the follow-up. The affricate /ʧ/ was realized correctly at the follow-up and moved from Type 5 to Type 1 knowledge. The voiced cognate /ʤ/ moved from Type 5 to Type 3. The nasal /ŋ/ changed from Type 2 to Type 1 phonological knowledge by the follow-up.

Table 75. Phonological knowledge continuum for Subject 6 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n ŋ p b t d k g f v h tʃ w j
	Type 2	l
	Type 3	ʃ ʤ
	Type 4	
	Type 5	ʧ s z
Least Knowledge	Type 6	θ ʒ r

Performance summary for Subject 6

Subject 6 did not show significant increases in the correct production of clusters, moving from a pretraining level of 1% to only 4% by the follow-up. The occurrence of cluster production (either correct or incorrect) increased from 3% to 21%. There was no change in production of /sp/, /st/, /sk/, or /br/ clusters, with no correct productions at the pretraining or follow-up samples. The correct production of initial strident singletons increased from 49% to 73% over the course of the investigation. No such increases were observed for the feature of stridency because of the inclusion of the /s/ plus consonant clusters.

Several changes were evidenced in the phonological knowledge continuum for Subject 6 over the course of the study. There was movement toward the correct adult target for the phonemes /f/, /v/, /z/, /ʃ/, and /ð/. The stops were all categorized as Type 1 knowledge by the follow-up. The fricatives /f/ and /v/ were realized correctly by the follow-up. The palatal /ʃ/ moved from Type 5 to type 3. The phonemes /z/ and /ð/ changed from Type 6 to Type 5 at the follow-up.

Considerable change occurred in the phonological deviancy scores derived from the APP--R. John had a follow-up score of 37 compared to the pretraining score of 55. He had moved from the severe to the moderate category by the follow-up.

It is evident from the data that the phonological system of Subject 6 was in the process of change. These changes appeared to be in the direction of correct, adult-like realizations. However, the production of clusters remained a significant problem for Subject 6. Thus, it is hypothesized that while the treatment did not have a direct result on the production of clusters, phonological remediation did serve to facilitate changes in John's production of singletons, particularly strident fricatives.

Performance summary for Group 2: Severe

All subjects in Group 2 showed a slight increase in correct cluster production. The range of correct cluster production for Subjects 4, 5, and 6 was 4% to 6%. Subjects 4 and 5 showed increases in the production of the target clusters /sp/ and /st/ with percentages of 21% and 2%, respectively. Some generalization to the untrained /sk/ cluster was observed for Subjects 4 and 5; however, the percentage correct was below 5%. Subject 6 did not demonstrate significant changes in his production of consonant clusters.

There appeared to be some generalization of the strident feature for all subjects, although the type of generalization differed across the subjects. Subject 4 had a slight increase in the production of stridency, with the inclusion of /s/ plus consonant clusters. For Subject 5, increases in correct initial strident singletons, as well as overall

stridency, were evidenced. Subject 6 had significant increases in the production of initial strident singletons with a final percentage of 73. Thus, changes did occur in the speech samples of these three subjects. However, the extent and breadth of the changes were not as great as the Group 1 subjects.

Summary of Results

Question 1: The effect of severity on generalization following cluster training. Based on the results of the individual phonological assessments, it does appear that the severity rating from the APP--R could have been used as a predictor of generalization of training for the elimination of cluster reduction. The subjects with moderate severity levels evidenced greater generalization than the subjects with severe ratings. Of the six subjects, only one, Subject 2, had a lower phonological deviancy score at the follow-up than at the pretraining evaluation. This subject also had low levels of correct production of the training clusters /sp/ and /st/ (6%) and the untrained cluster /sk/ (4%). However, other subjects, Subjects 5 and 6, had equally low or lower levels of correct production of these clusters. Thus, the use of severity as a gauge of possible amounts of generalization may serve as a gross estimate of progress, with subjects with moderate severity ratings making greater progress than their counterparts with severe ratings.

Question 2: The effect of phonological knowledge on generalization following cluster training. Changes in the phonological knowledge continua did occur for all six subjects. Each subject showed change in at least 5 different phonemes, with a range of 5 to 9 phonemes changing from the pretraining sample to the follow-up evaluation. However, the changes were mixed, with most of the phonemes evidencing change moving toward the most-knowledge end of the continuum (73% of the total sample). However, no clear patterns were observed. Those subjects in the moderate group that showed the greatest amount of generalization of training did not show the greatest change in the phonological knowledge continua.

Thus, it did not appear that an analysis of phonological knowledge provided insight into a given subject's progress in the training program, or served as a predictor of generalization in the training of /s/ plus stop clusters. Given that the remediation targets were chosen irrespective of the placement of the individual phonemes on the phonological knowledge continuum, the actual function of the continuum may have been bypassed.

Question 3: The effect of severity on generalization one month following cluster training. All subjects showed increases in correct productions at the follow-up evaluation. These increases were evidenced differently for each subject, but the increases did occur for the /s/ plus stop clusters

and for the overall stridency feature. Subjects 1, 2, and 3 had the greatest increases in correct production for both correct cluster production and /s/ plus stop cluster production.

All subjects with the exception of Subject 6 did exhibit generalization of the /s/ plus stop training to untrained stimuli. Increases in the correct production of /sk/ were observed in Subjects 1 through 5. All subjects showed increased production of correct clusters by the follow-up indicating a generalization of the consonant cluster form in the initial position. For the feature of stridency, Subjects 2, 5, and 6 evidenced increased production of correct initial stridents. For Subjects 1 and 4, there were drops of only 1% for each. Subject 3, however, moved from a pretraining accuracy level for initial strident singletons of 94% to 87% by the follow-up.

Thus, a broad statement can be made regarding generalization. All subjects involved in a remediation program for /s/ plus stop clusters demonstrated generalization of the trained stimuli to untrained stimuli. The generalization occurred on two parameters, cluster production and stridency. However, one broad statement can not be made regarding the amount of generalization or the breadth of generalization. Each subject followed an individual pattern of learning with differing levels of accuracy across the course of the investigation.

Question 4: The effect of individual differences on the amount of generalization. Whereas individual differences were observed among the subjects, no specific differences can be attributed to the success or failure of a given child to generalize the trained stimuli. However, some interesting observations should be made about the subjects.

For Subject 2, the process of final consonant deletion may have interfered with progress on the training clusters. Although the training involved initial consonants, Subject 2 may not have been ready to begin work on these targets. More success may have occurred if elimination of final consonant deletion was targeted prior to work on consonant clusters.

Subject 3 was inattentive during many sessions over the course of the study. It was necessary to allow several breaks during any one session. This inattentiveness may have hindered his overall progress. He responded correctly during the training portion of each session, but was not able to maintain the correct productions for the generalization probes. Also, these correct productions were not incorporated into his phonological system.

Subjects 4 and 5 evidenced a significant amount of stopping of fricatives at the beginning of the investigation. It is hypothesized that this pattern would hinder progress on the target /s/ plus stop clusters. The stopping of fricatives and affricates may serve to make to phonological system more resistent to change in the feature of stridency.

There were increases in the production of stridency during training for both subjects. However, by the follow-up, the percentage of stridency had dropped close to the pretraining levels. Training on the [+ continuant] feature prior to training /s/ plus stop clusters may have resulted in more positive changes.

Subject 6 appeared to be highly stimulable, with changes in production noted across the baselines based on auditory input only. After hearing the production, Subject 6 would produce given phonemes correctly. However, in spontaneous productions, these same phonemes were produced incorrectly. It appeared that Subject 6 was a highly auditory learner. However, his improved productions during probe measurements were not reflected in the follow-up percentages. This suggests that the changes were not incorporated in his phonological system.

SUMMARY AND DISCUSSION

Overview

The purpose of this investigation was to examine the relationship between severity of phonological disability and generalization in preschool children. Two severity groups, moderate and severe, were determined through the administration of the APP--R. The single-subject research design chosen for this investigation was the multiple baseline across subject design. All subjects within a given severity level served as controls for the other subjects at that level. One subject from each of the two severity groups received training while the remaining subjects were followed in baseline. Following baseline measurements, training of the /s/ plus stop clusters /sp/ and /st/ was initiated. Generalization probes which included untrained /sp/ and /st/ clusters, as well as /sk/ clusters and initial strident singletons, were administered following each training session. Additionally, a control cluster /br/ was followed as an additional within-subject controlling factor.

Additional Subject

Through the University of Florida Speech and Hearing Clinic, an additional subject was available. Study of this child was initiated because his phonological disorder was in the profound range of severity based on the results of the

APP--R. Although he was not considered in analysis of the results, he completed the identical training as the other six subjects. The results for Subject 7 are presented in the same format as those in the formal results section.

Subject 7

Background information

Subject 7, Eric, was aged 5 years, 1 month at the beginning of the study. He was the product of an unremarkable pregnancy, and all developmental milestones were within the normal range. Eric's parents first noticed his speech problem when he was about age three. He is the youngest of two children, with a sister four years older. At the time of the study, Eric was enrolled in a daily preschool program.

Test performance

On the PLS, Eric achieved an auditory comprehension age of 5:10-1/2 (years:months) and verbal ability age of 5:3 for an overall language age of 5:8-1/4. On the PPVT--R, Eric achieved an age equivalency of 5:1. Thus, language skills were within normal limits. Pure tone audiometric screening revealed normal thresholds. Tympanometry also revealed normal middle ear functioning. Initial evaluation results are summarized in Table 3.

On the APP--R, Eric achieved a phonological deviancy score of 77, placing him in the profound range (60 or above) of severity. A detailed summary of his performance on the APP--R can be found in Table 76. Five points were added to

Table 76. Phonological analysis summary based on results from the Assessment of Phonological Processes -- Revised for Subject 7.

Basic Phonological Processes	% of Occurrence Pretraining	Follow-up
Phonological Omissions		
Syllable Reductions	5	21
Consonant Sequence Reduction	103	98
Consonant Singleton Omissions		
Prevocalic	0	0
Postvocalic	65	65
Class Deficiencies		
Stridents	93	81
Velar Obstruents	91	100
Liquid (l)	91	91
Liquid (r,ɝ)	100	100
Nasals	11	0
Glides	60	50
Total	619	606
Mean	62	61
Age Points (CA of 5:0 = 10)	10	10
Additional Points (Backing > 5)	5	5
Phonological Deviancy Score	77	76
Severity Rating	PROFOUND	PROFOUND

his phonological deviancy score due to the presence of 5 or more occasions of backing (Hodson, 1986). The percentage of occurrence of consonant sequence reduction, including consonant clusters, was 103%, representing the largest percentage in the phonological omission category. Postvocalic singleton omission was also a frequently occurring process at 65%. All class deficiencies, with the exception of the nasal class, were frequently occurring. The liquid /r,ɝ/ class had a percentage of occurrence of 100%, with stridents at 93%, velar obstruents and liquid /l/ at 91%, and glides at 60%.

Pretraining phonological evaluation

Phonetic inventory. The full complement of nasals, stops, affricates, and glides were present in Eric's pretraining phonetic inventory (Table 77). The glottal stop was also present. The fricatives /v/, /ð/, /z/, /ʃ/, and /h/ were evidenced, as was liquid /l/.

Phonetic realizations for consonant singletons. The singleton realizations of Subject 7 will be described briefly by manner-of-articulation class. Phonological rule statements and accompanying examples are presented in Appendix L. Due to the application of of phonological processes in context-specific situations, the descriptions of Subject 7 will be based on position rather than individual phonemes. Eric's approach to fricatives was consistent and rule-governed. The phonetic realizations of the fricatives are

Table 77. Pretraining phonetic inventory for Subject 7 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	v	ð	z	ʃ		h
Affricate				ʧ ʤ		
Approximant	w		l	j		

presented in Table 78. Word initial voiceless fricatives were produced as [h], although /ʃ/ became [t] on two occasions. The word initial voiced fricatives were more variable, but typically, these targets were produced as a glide, homorganic stop, or in the case of /v/, occasionally the correct fricative. All intervocalic fricatives were affected by reduplication of the initial syllable. The consonant beginning the second syllable was identical with the consonant beginning the first syllable. For example, the word coughing was realized as [tɔtɔ], shovel as [hʌhʌ], fishing as [hɪhɪ], and feather as [hɛhɛ]. Word final fricatives were either omitted or replaced by [ʔ] or both. In two examples, word final /s/ was replaced by [ʃ].

Eric's phonetic realizations of the stops and affricates are presented in Table 79. Whereas some correct productions were observed in some positions, no single stop or affricate was realized correctly in all positions. The labial and alveolar stops were produced correctly in the initial position. Fronting of velars was observed in the initial realizations of /k/ and /g/, with /k/ replaced by [t], and /g/ replaced by [d]. The affricates in the initial position were produced correctly in some examples and reduced to the expected stop in others. Only /p/ and /b/ appeared correctly in the intervocalic position. Other stops and affricates were affected by the reduplication of the initial syllable. Word final stops were often correct, but also alternated with

Table 78. Summary of pretraining phonetic realizations of the fricatives for Subject 7.

Phoneme	Position		
	Initial	Intervocalic	Final
f	h	reduplication	ʔ ~ ø
v	w ~ v ~ b	reduplication	ø
θ	h		ø ~ ʔ
ð	d ~ ð		
s	h	reduplication	ø ~ ʔ ~ ʃ
z	w ~ j ~ d	reduplication	ø
ʃ	h ~ t	reduplication	ʔ ~ ø
h	h		

Table 79. Summary of pretraining phonetic realizations of the stops and affricates for Subject 7.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p	p	p ~ ʔ
b	b	b	ø
t	t	reduplication	ʔ ~ t ~ ø
d	d	reduplication	ø
k	t	reduplication	ʔ ~ k ~ ø
g	d	reduplication	ø ~ g
ʧ	t ~ ʧ	reduplication	ø
ʤ	d ~ ʤ	*	ø

Note: [*] denotes insufficient evidence to determine realization.

[ʔ], or were omitted, or both. Voiced final stops and both affricates were always omitted or replaced by the glottal stop.

The phonetic realizations of the nasals, liquids, and glides at the pretraining evaluation are presented in Table 80. The labial and alveolar nasals were produced correctly in all positions, although the intervocalic nasals had no singleton examples. Final /ŋ/ was produced correctly or omitted. Liquid /l/ and /r/ (Table 80) were replaced by the glide /w/ in the initial position, as was intervocalic /r/. Inter-vocalic /l/ was affected by reduplication of the initial syllable. Final /l/ was produced correctly in some examples, and omitted or vowelized in other examples. The glides were correct in the initial position, but reduplication precluded the determination of the intervocalic realizations.

Cluster realizations for consonant clusters. The only clusters occurring in Eric's pretraining sample for the target clusters were two instances of [bw] for /br/. A summary of cluster realizations for Subject 7 can be found in Table 81. Eric's realizations of clusters appeared to involve ordered rules. The /sp/ cluster was usually reduced to the expected stop [p], sometimes with voicing added ([b]). A parallel realization was evidenced for /st/, with the cluster reduced to the expected stops [t] or [d]. An ordered phonological rule appeared to be operating in the realization

Table 80. Summary of pretraining phonetic realizations of the nasals, liquids, and glides for Subject 7.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	reduplication	m
n	n	reduplication	n
ŋ			ŋ ~ ø
l	w	reduplication	l ~ ø ~ v
r	w	w	
w	w		
j	j	j	

Table 81. Cluster realizations for Subject 7 at the pretraining and follow-up evaluations.

Pretraining	Follow-up
sp ---> p ~ b	sp ---> sp ~ p
st ---> t	st ---> st ~ t
sk ---> d ~ k	sk ---> st ~ t ~ d
sl ---> h	sl ---> h ~ s:h ~ s
sn ---> n	sn ---> sn ~ n
sm ---> m	sm ---> sm ~ m
br ---> b ~ bw	br ---> sp ~ b

of /k/ which became [d ~ k]. There were two possible paths for the realization of /sk/ as [d]. One possibility involves the fronting of the velar /k/, resulting in the cluster [st] that was then reduced to [d] as described above. The second path involves first, the reduction of the cluster to the expected stop [k], followed by the fronting of the velar to [d]. Further, the /sl/ cluster was realized as [h] that may be explained by the application of two ordered rules. The cluster may be reduced to the fricative [s] that is then replaced by [h]. The /s/ plus nasal stops were reduced to the expected nasal. The examples of Eric's cluster attempts are presented in Appendix L.

Homonyms. Subject 7 produced homonyms for 46% of the pretraining sample set. Intelligibility was severely affected by this loss of contrasts. Eric's speech was essentially unintelligible to a naive listener if the topic was not shared.

Phonological knowledge. A continuum of phonological knowledge for Subject 7 is presented in Table 82. Phonemes realized correctly in all positions were considered adult-like, and were assigned knowledge Type 1. The Type 1 phonemes from Eric's sample were /h/, /m/, /n/, /w/, and /j/. The phonemes /p/ and /ŋ/ were assigned Type 3 knowledge that is characterized by some correct examples in all positions, but not for all morphemes. The stops /b/ and /d/ were assigned Type 4 phonological knowledge. Type 5 phonological

Table 82. Phonological knowledge continuum for Subject 7 at the pretraining evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n h w j
	Type 2	
	Type 3	ŋ p
	Type 4	b d
	Type 5	t k g v ʧ l
Least Knowledge	Type 6	f θ s z ʃ ʤ r

knowledge is evidenced by some correct productions in at least one position, but not for all morphemes. The phonemes /v/, /ð/, /t/, /k/, /g/, /ʧ/, and /l/ were assigned Type 5 knowledge. Finally, those phonemes not in Eric's phonetic inventory, i.e, /f/,/s/, /z/, /ʃ/, /θ/, /ʤ/, and /r/, were considered type 6 or non-adult-like.

Baseline measurements

Because Subject 7 was the only child with a phonological deviancy score in the profound range, only three baseline measurements were taken prior to the initiation of training. Eric's performance across time, beginning with the pre-training evaluation, and including the baseline measurements, the probe measurements, and the follow-up evaluation, is presented in Figures 20, 21, and 22. Performance remained stable for all baseline measures. During the baseline measurements, no correct clusters were produced (Figure 20). The percentage of initial strident singletons produced correctly did not fluctuate significantly with a range of 1% to 9% observed across the baselines (Figure 20). Additionally, no /s/ plus stop clusters or control clusters were produced correctly during any of the measurements (Figure 21). Finally, percentage for overall consonant cluster production (either correct or incorrect) and the feature of stridency (including clusters) were computed and are presented in Figure 22. Changes in either of these measures could reflect changes in the child's phonological

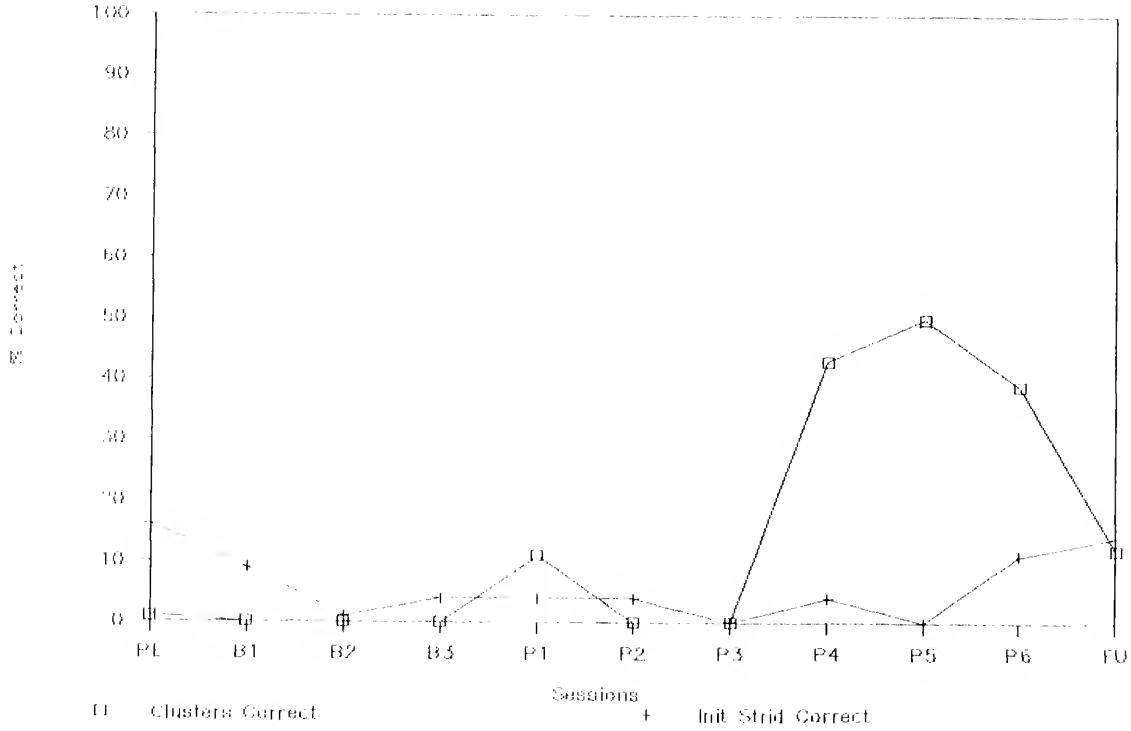

Figure 20. Performance of Subject 7 on correct cluster production and correct initial strident singletons at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

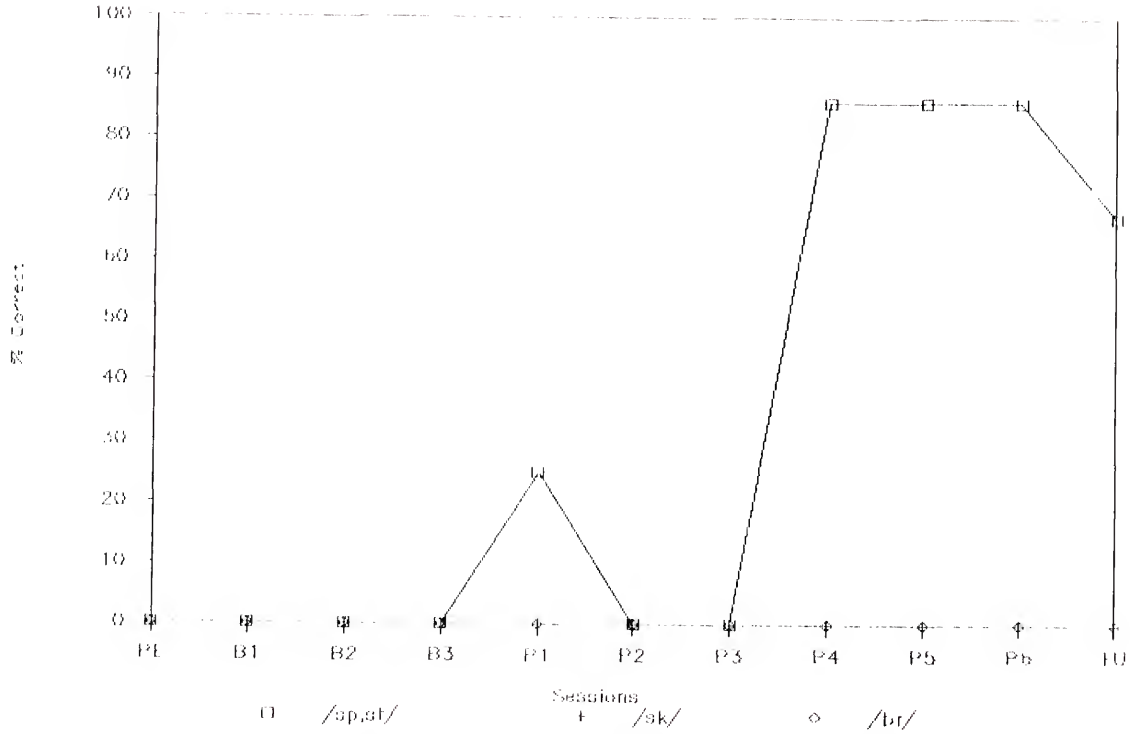

Figure 21. Performance of Subject 7 on the clusters /sp/ and /st/, /sk/, and /br/ at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

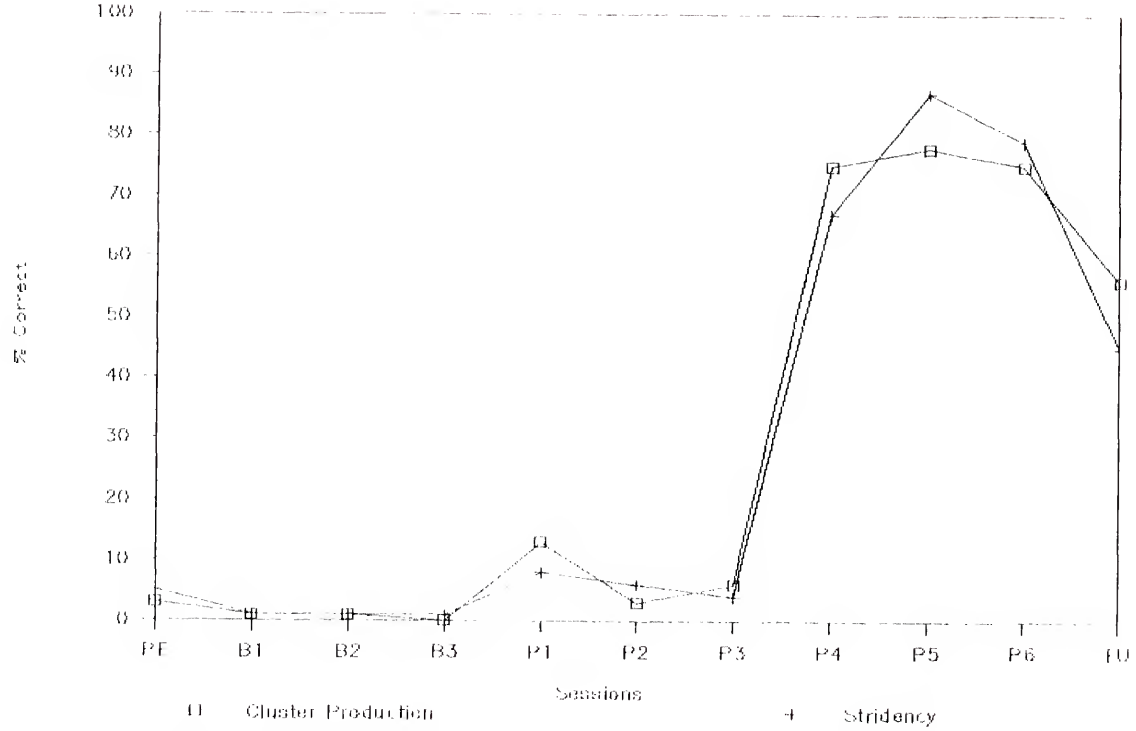

Figure 22. Performance of Subject 7 on overall cluster production (either correct or incorrect) and overall stridency (including /s/ clusters) at the pretraining evaluation (PE), baseline (B), generalization probes (P) and the follow-up evaluation (FU).

system not measured by the correct/incorrect dichotomy. Overall cluster production remained stable, with 1% correct for the first two baselines, and no clusters evidenced in the third baseline. The percentage of stridency for those initial consonants that should have been produced as strident, including /s/ clusters, also remained stable at 1% across the three baselines.

Probe measurements

Criteria for discontinuing treatment was reached at the sixth training session. Increases in correct cluster production (Figure 20) were noted with a low of 11% at Probe 1 and a high of 50% at Probe 5. The percentage of correct cluster production at the sixth and final probe was 39%. No significant changes were observed in the correct production of strident singletons with a range of 0 to 11% across the probes (Figure 20). It should be noted that the highest percentage (14%) occurred at the last probe. It can be seen that there were no correct productions of the control cluster /br/ over the course of training (Figure 21). There was change, however, in the target clusters, /sp/ and /st/ (Figure 21) from 25% correct in Probe 1 to 86% correct at the fourth, fifth, and sixth probes. No correct productions of /sk/ were evidenced over the course of training (Figure 21), primarily because /sk/ was replaced by [st].

However, there was a significant increase in the feature of stridency (Figure 22) from 8% at Probe 1 to 79% at Probe

6. An interesting increase in overall cluster production (Figure 22) occurred during the course of training. There was an increase from 13% cluster occurrence in Probe 1 to 75% cluster occurrence in Probe 6.

Follow-up phonological evaluation

Test performance. As indicated in Table 76, a slight improvement in performance on the APP--R was observed between the pretraining level and the final evaluation, some two months later. During the initial evaluation, Eric had a phonological deviancy score of 77 compared to a final phonological deviancy score of 76. Both scores are within the profound range (60 or above).

Consonant sequence reduction and postvocalic consonant singleton omissions remained the highest phonological omissions with 98% and 65%, respectively. Whereas a drop in the percentage of occurrence of consonant sequence reduction from 103% to 98% was observed, the occurrence of postvocalic consonant singleton omissions remained the same at 65%. No changes were evidenced for the liquid /l/ and /r,ɝ/ class deficiencies. However, increases in velar obstruent class deficiencies were noted. Strident and glide class deficiencies decreased from the pretraining evaluation to the follow-up.

Phonetic inventory. The phonetic inventory for Subject 7 had changed from the pretraining sample to the follow-up sample (Table 83) in several ways. Most changes were noted

Table 83. Follow-up phonetic inventory for Subject 7 with marginal phones indicated by parentheses.

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Nasal	m		n		ŋ	
Plosive	p b		t d		k g	ʔ
Fricative	f (v)		s	ʃ		h
Affricate				(tʃ) dʒ		
Approximant	w		l	j		

in the fricative class, with /f/ and /s/ added to the final phonetic inventory and /v/ changing to a marginal phone. Whereas the sounds /θ/ and /z/ were present in the pretraining phonetic inventory, they were not present by the follow-up. The affricate /ʧ/, present in the pretraining phonetic inventory was only a marginal phone in the follow-up sample. All other aspects remained constant.

Phonetic realizations for consonant singletons. Phonological rule statements and accompanying examples are presented in Appendix L. The phonetic realizations of the fricatives are presented in Table 84. The voiceless fricatives continued to be produced as [h] in the initial position. However, some overgeneralization was evidenced in the addition of [s] before the [h]. Although not occurring in the realization of /θ/ and /h/, this overgeneralization did occur for all other voiceless fricatives. There were also two instances of initial /ʃ/ produced correctly. At the pretraining evaluation, the voiced fricative /v/ was either replaced by the glide [w] or reduced to the homorganic stop. By the follow-up, /v/ was still replaced by [w] in some examples. However, some correct productions were present, as well as overgeneralization evidenced by the addition of [s] before the [w]. In most instances, initial /z/ was replaced by the homorganic stop. However, overgeneralization by the addition of [s] to the earlier used glide, or by the addition of a whole /s/ plus stop cluster was observed. For example,

Table 84. Summary of follow-up phonetic realizations of the fricatives for Subject 7.

Phoneme	Position		
	Initial	Intervocalic	Final
f	h ~ s:h	reduplication	?
v	sw ~ w ~ b	reduplication	ø
θ	h		? ~ ø
ð	d		
s	h ~ s:h	reduplication	s ~ ø ~ ?
z	sw ~ d ~ st ~ h	reduplication	ø
ʃ	h ~ s:h	reduplication	?
h	h		

the word zoo was produced as [swu], and zip was produced as [stɪp]. As at the pretraining, the process of reduplication affected the intervocalic fricatives, precluding the determination of these realizations. The word final voiced fricatives were omitted in all instances. Word final voiceless fricatives /f/ and /ʃ/ were replaced by the glottal stop. The most change in the final position occurred in the realization of final /s/. This phoneme was either omitted, replaced by the glottal stop, or produced correctly. There were six instances of correct production of /s/ in the final position.

The phonetic realizations of the stops and affricates are presented in Table 85. By the follow-up evaluation, much change had occurred in the realizations of the stop phonemes (Table 85). Overgeneralization of /s/ clusters could account for the changes in initial /p/, /b/, and /k/. Initial /p/ and /b/ were produced correctly in some examples and were produced with an additional [s] in others, e.g., pig was produced as [spɪ], and boats was produced as [sb$\overline{\text{oʊ}}$]. The velar fronting rule, affecting /k/, was also evidenced at the follow-up. The phoneme /k/ was fronted to the [t] in some examples and was produced as [st] in others. Initial /t/ and /d/ were produced correctly. Eric had an interesting context-specific rule operating for some examples containing intervocalic /t/. The /t/ was produced correctly in the environment of abutting consonants when the target followed

Table 85. Summary of follow-up phonetic realizations of the stops and affricates for Subject 7.

Phoneme	Position		
	Initial	Intervocalic	Final
p	p ~ sp	p ~ m	p
b	b ~ sb	*	ø ~ b
t	t	reduplication	ø ~ t ~ ʔ
d	d		ø
k	t ~ st	reduplication	ʔ ~ ø ~ k
g	d	*	ø
ʧ	t	reduplication	ʔ
ʤ	st ~ d ~ ʤ	reduplication	ø

Note: [*] denotes insufficient evidence to determine realization.

/n/. For example, pretend was produced [əntɪn], and valentine was produced [dæləntaɪn]. The process of reduplication affected the determination of the intervocalic realizations of some stops and the affricates. Additionally, the data set did not provide adequate evidence for determination of other intervocalic realizations of stops. Word final voiced stops and affricates were omitted in all instances, with one exception. There were three instances of final /b/ produced correctly. The word final voiceless stops and affricates were usually omitted, or replaced by the glottal stop, or both. The final /t/ and /k/ were also produced correctly in some examples.

The phonetic realizations of the nasals, liquids, and glides are presented in Table 86. The labial and alveolar nasals were produced correctly in all positions. Intervocalic /ŋ/ was produced correctly, and final /ŋ/ was produced correctly in some examples, replaced by [n], or omitted in others. Liquid /l/ continued to be replaced by the glide [w]; however, the target appeared to be emerging in the intervocalic position, with the realization of [l ~ w]. Final /l/ was produced correctly in some examples and omitted in others. Initial /r/ remained the same with [w] serving as the phonetic realization. Initial /w/ was realized as [w ~ sw] at the follow-up compared to [w] only at the pretraining sample. The palatal glide /j/ continued to be produced correctly in the initial and intervocalic positions.

Table 86. Summary of follow-up phonetic realizations of the nasals, liquids, and glides for Subject 7.

Phoneme	Position		
	Initial	Intervocalic	Final
m	m	m	m
n	n	n	n
ŋ		ŋ	∅ ~ n ~ ŋ
l	w	l ~ w	l ~ ∅
r	w		
w	w ~ sw		
j	j	j	

Phonological realizations for consonant clusters. A summary of the Eric's cluster realizations at the follow-up can be found in Table 81. By the follow-up evaluation, Subject 7 was producing some correct clusters (Figure 20). Percentage of clusters correct went from a pretraining level of 1% to 12% at the follow-up. The /sp/ and /st/ clusters (Figure 21) were realized correctly in some examples, and reduced to the expected stop in others. There were no correct productions at the pretraining sample; however, 56% were correct at the follow-up. The /sk/ cluster (Figure 21) continued to be affected by the velar fronting rule, and was realized as [st~t~d] by the follow-up. The emergence of /s/ in the /sl/ clusters was observed in the follow-up sample, with a realization of [h~s:h~s]. The /sl/ cluster was still affected the ordering rule taking /sl/ to [h], but not as much as at the pretraining sample. The /s/ plus nasal clusters were realized correctly in some examples, and reduced to the expected nasal in others. The control cluster /br/ (Figure 21) was affected by overgeneralization of training, and was produced as [sp~b] by the follow-up. Percentage of overall cluster occurrence (Figure 22) had increased from a 3% level at the pretraining sample to 56% at the follow-up. Examples of Eric's cluster attempts are presented in Appendix L.

Homonym sets. Subject 7 produced homonyms for 34% of the follow-up sample set compared with 46% at the pretraining

evaluation. Intelligibility remained severely affected by the loss of contrasts.

Phonological knowledge. From the pretraining sample to the follow-up evaluation, changes were observed in the phonological continuum (Table 87). The fricatives /s/ and /ʃ/ had changed from Type 6 phonological knowledge to Type 5 at the follow-up. The stops /b/ and /t/ were assigned Type 3 knowledge, changing from Type 4 and Type 5, respectively. Four phonemes, /v/, /ð/, /g/, and /tʃ/, moved from Type 5 phonological knowledge at the pretraining sample to Type 6 knowledge at the follow-up.

Performance summary for Subject 7

Subject 7 evidenced increases in correct cluster production from 1% to 12% from the pretraining sample to the follow-up. A significant increase in overall cluster production (either correct or incorrect) was also noted with a follow-up level of 56% compared with the pretraining level of 3%. Whereas no correct productions of the untrained /sk/ cluster or the control cluster /br/ were evidenced across the course of the investigation, the trained clusters /sp/ and /st/ did show significant increases from 0 at the pretraining evaluation to 67% by the follow-up. No significant changes occurred in the percentage of correct initial strident singletons by the follow-up. However, the feature of stridency did increase from 5% to 45% over the course of training.

Table 87. Phonological knowledge continuum for Subject 7 at the follow-up evaluation.

Continuum	Phonological Knowledge Type	Phonemes
Most Knowledge	Type 1	m n h j w
	Type 2	
	Type 3	ŋ p b t
	Type 4	d
	Type 5	k s ʃ l
Least Knowledge	Type 6	g f v θ ð z tʃ dʒ r

The continuum of phonological knowledge had changed at the follow-up. Two fricatives, /s/ and /ʃ/, and the affricate /ʤ/ moved toward the most-knowledge end of the continuum. Four phonemes moved to Type 6 knowledge at the follow-up. These phonemes, /v/, /ð/, /g/, and /ʧ/ were not evidenced in Eric's follow-up realizations.

Little change was seen in performance on the APP--R. Subject 7 had a pretraining phonological deviancy score of 77 compared with a follow-up score of 76. Both scores place Subject 7 in the profound range of severity.

In summary, Subject 7 did indeed maintain correct production of the target clusters /sp/ and /st/. However, generalization to untrained clusters did not occur. There was some generalization of the feature of stridency due in part to the increased percentages of correct /sp/ and /st/ clusters.

Research Questions

The research questions posed for the purposes of the investigation dealt with the relationships among severity of phonological disability, amount of phonological knowledge, and generalization learning. The research questions are presented below with results summarized for all subjects and implications discussed.

Question 1: Will there be differences in the amount of generalization made by the subjects based on their severity rating on the Assessment of Phonological Processes--Revised

following an /s/ cluster training program? The subjects with phonological deviancy scores within the moderate range of severity showed greater increases in the correct production of clusters than did the subjects with severe ratings. No other general statements that would be true across all three subjects in the moderate group could be made. All three subjects in the severe group evidenced improvements in their phonological deviancy scores upon readministration of the APP--R. This improvement occurred for Subjects 1, 3, and 7 also. Subject 2 evidenced a decrease in his phonological deviancy score at the follow-up evaluation. Whereas some differences occurred across the two groups (with Subject 7 excluded), these may in fact be due to within-subject differences rather than due to between-group differences. However, there was more generalization of learning in the performance of Group 1 than Group 2. Thus, the use of severity as a gauge of possible amounts of generalization may assist in making prognostic statements. Furthermore, the APP--R may prove useful in other experimental situations requiring the division of subjects into groups based on severity of phonological disorder.

It is possible, however, that the training program did not provide for the most effective use of the diagnostic information provided by the assessment tool. However, division into severity groups provides one means of testing the hypothesis of differing performances based on degree of

phonological disability. Greater changes in the children's phonological systems may have be evidenced if the training targets were individually chosen based on each child's APP--R results, rather than chosen prior to the complete analysis of each child phonological system.

Question 2: Will there be differences in the amount of generalization made by subjects based on their phonological knowledge following a phonological remediation program? Although positive changes were evidenced in the phonological knowledge continua for all subjects, the amount of generalization made by any given subject could not be predicted by the pretraining knowledge continuum. Additionally, no statements about overall generalization of learning could be made based on comparison of the pretraining and follow-up phonological knowledge continua. It must be noted that the original purpose of the phonological knowledge continuum as described by Elbert and Gierut (1986) was to describe the individual systems of phonologically disordered children and to explain individual differences in generalization learning. The use of an assessment tool, like the APP--R that is designed to identify phonological processes, as the primary method of determining the presence or absence of a given phonological process, may not allow the phonological knowledge continuum to be utilized to its fullest extent. Further evaluation and reanalysis of the data set might provide insight into sound changes not

highlighted in this investigation, but reflected in gradual changes in the knowledge continuum.

Question 3: Will there be differences in the amount of generalization when evaluated one month following termination of training? All subjects with the exception of Subject 6 showed increases in the frequency of correctly produced target clusters /sp/ and /st/, with a range of 2% to 67%. Subjects 7, 3, and 1 had the highest percentages of correct production of /sp/ and /st/ with 67% reported for Subjects 7 and 3, and 59% reported for Subject 1. The overall training program must be considered successful given these increases. However, the generalization of the training to the untrained /s/ plus stop cluster /sk/ occurred for Subjects 1 through 5 only. The range of correct /sk/ productions was 3% to 64%, with the following individual percentages evidenced: 57% for Subject 1; 4% for Subjects 2 and 5; 64% for Subject 3; and 3% for Subject 4. It must be noted that for Subject 7, the presence of a velar fronting rule precluded the correct production of /sk/ clusters. However, by the follow-up, Subject 7 produced [st] clusters for the /sk/ target. The presence of such ordering rules was reported earlier by Compton (1975).

All seven subjects showed increases in the frequency of overall cluster production, as well as increases in the amount of correct cluster production. For correct cluster production, the percentages ranged from 3% to 49% with

Subjects 1, 2, and 3, evidencing the greatest increases, with 49%, 14%, and 34%, respectively. For overall cluster production (either correct or incorrect), Subjects 7, 3, and 1 had the greatest increases with 53%, 49% and 43% reported. The range of increases for cluster production was 5% to 53%.

Thus, it can be stated that regardless of severity, all subjects did generalize the training of /s/ plus stop clusters. The phonological remediation program was successful. Given its gradual nature, further generalization may have occurred at a later date. Measurement of progress at two months post-training may have revealed improved cluster productions because the subjects would have had more time to incorporate the training into their systems. This is speculation, at best. However, Ingram (1983) reported that perception of the target generally precedes production. In a later work, Ingram (1986) mentioned that there was a lag of several months between the first perception and production in other aspects of language, as well as phonology. It is possible that the subjects did change their perception of the target but time constraints did not allow for an adequate measure of the later occurring production changes.

Question 4: Can differences in the amount of generalization be explained by individual differences among children? Although some possible differences among children were identified in the previous chapter, it is not possible to quantify these differences. The children showed differing

patterns of learning, with some evidencing generalization to the untrained /sk/ cluster as well as to other /s/ plus consonant clusters. Other children correctly produced the target clusters but no generalization was noted for other untrained stimuli. Given that differing amounts of generalization was evidenced between children, the notion of individual differences becomes paramount in the the determination of treatment goals, as well as treatment program. Stoel-Gammon and Dunn (1985) emphasized the importance of considering the phonologically disordered child as a unique individual. Perhaps the application of a system such as that proposed by Elbert and Gierut (1986), which determines a child's underlying knowledge of phonemes, would be helpful in the explanation of individual differences. This explanation of individual differences is the basic principle underlying the use of the knowledge continuum.

An interesting change was noted for Subject 6. Although there was little change in the production of correct clusters or in the production of the /s/ plus stop clusters, the consonant sequence reduction score on the APP--R dropped considerably between the pretraining administration and the follow-up. The pretraining percentage of occurrence was 125% compared to 65% at the follow-up. Whereas these changes were not reflected in the frequency counts for correct cluster production, the frequency of occurrence of overall clusters did increase from 0 to 21%. At the initial administration of

the APP--R, John deleted the entire cluster in most instances, e.g., string ---> [ɪŋ]. By the follow-up, one or more members of the cluster was present, e.g., string ---> [twɪŋ]. Further, John appeared to be in the process of developing the consonant plus liquid clusters. In the early stages of the study, these clusters were usually reduced to the non-liquid consonant, e.g., braid ---> [bɑ̄ɪd]. In some instances, coalescence was also observed, e.g., brew ---> [fu]. However, later in the study, John produced an epenthetic glide between the two elements of the cluster. However, the liquid was usually replaced by the glide [w], e.g., bring ---> [bəwɪŋ]. By the close of the investigation, John was producing a cluster with the liquid still replaced by the glide, bread ---> [bwɛd]. This sequence was outlined earlier by Gilbert and Purves (1977). Thus, the phonological system of Subject 6 did in fact change in relation to clusters. However, these changes were not reflected in many of the frequency counts reported.

The assessment tools used in this investigation, the APP--R and the generative phonological assessment, are from the works of Hodson (1986) and Elbert and Gierut (1986), respectively. To develop some perspective about the findings of this present research, it is necessary to review the basic principles and strategies proposed by these individuals. Although the two groups were determined by the use of the APP--R, the treatment program outline by Hodson (1986) was

not followed. The "cycle" approach refers to the targeting of several phonological processes in a given time period and then repeating the same treatment with different stimuli. The present investigation did not provide for movement from one process to another, nor did it allow for choice of the target process to be based on individual performance on the APP--R.

The use of the knowledge continuum for this study did not appear to predict the extent of generalization learning for any subjects. However, it must be emphasized that the use of this continuum is only one part of a treatment program outlined by Elbert and Gierut (1986). The choice of a "process" rather than a series of phonemes violates the basic principles of the Elbert and Gierut remediation program. The child's phonological knowledge is to be used to determine therapy goals, and the choice for the clinician then becomes which end of the continuum to target in the initial stages of treatment.

Because three of the six subjects continued to be seen at the University of Florida Speech and Hearing Clinic, brief statements about their continued progress can be made. Subjects 2, 5, and 7 continued in remediation programs during the semester following the completion of this investigation. The remediation target for Subject 2 was final consonants, particularily stops, fricatives, and nasals. For Subject 6, stridency in /s/ plus consonant clusters and initial strident

singletons was targeted. The targets for Subject 7 were initial and final strident singletons. All three children continue to show positive changes in their phonological systems.

In summary, the use of a phonological remediation program targeting elimination of cluster reduction was sucessful and subjects did show differences in generalization based on their severity ratings. It would be interesting to reanalyze the data from these seven subjects to determine any sound changes that occurred over time, e.g., during the baselines and probes. The children may have actually followed a gradual development with quantifiable sound changes from the incorrect target to the final correct production. The use of a numeric scoring system that would allow for a ranking of correct, incorrect, and approximated responses would serve to document these gradual changes. Such a system has been outlined by Powell (1985) and was used in a study of cluster production by Dyson and Stewart (1987). Descriptions of the order of acquisition of various phonemes or clusters could provide valuable data to the current base of literature about phonological disorders.

In considering areas of needed research, there is a recurring call for research that compares differing approaches to phonological remediation. Although the broad goal of facilitating development of normal speech is at the root of all phonological remediation programs, the methods

and principles differ with each individual program. It would prove interesting to directly compare the cycle approach proposed by Hodson (1986) with the treatment approach outlined by Elbert and Gierut (1986). Before such comparisons can be made, more definite boundaries for the determination of the phonological knowledge types are needed. The word continuum does imply some flexibility; however, the assignment of a discrete type appears to remove some of this flexibility. As more research is conducted using the phonological knowledge continuum, it is possible that assignment to knowledge types will be made less difficult.

General Conclusions

1. All subjects evidenced increases in correct cluster production following the training program when reassessed one month following this training.
2. All subjects evidenced increases in overall cluster production (either correct or incorrect) from the pretraining sample to the follow-up.
3. All subjects evidenced increases in correct production of the training clusters /sp/ and /st/ during the training portion of the investigation. Increases from the pretraining levels were evidenced at the follow-up for Subjects 1, 2, 3, 4, 5, and 7.
4. Six of the seven subjects evidenced increases in the feature of stridency from the pretraining sample until the follow-up evaluation.

5. Changes in the phonological knowledge continuum for all subjects were noted. However, no significant changes that could be used as predictors of generalization, were observed in the placement of the fricative or stop classes.

APPENDIX A: LETTER OF EXPLANATION FOR PARENT

APPENDIX A: LETTER OF EXPLANATION FOR PARENT

This study is designed to investigate how children learn certain speech sounds and whether learning one sound affects the learning of others. Your child was chosen because he/she has difficulty producing certain sounds and sound combinations.

Your child will be evaluated in the areas of speech, language, and hearing. If he/she meets the criteria for the investigation, treatment will begin. Your child will be seen for twice weekly one-hour sessions until he/she is able to produce the speech target with 90% accuracy. It is expected that this will take from one to six sessions for each of the two sounds. Following the treatment, your child will be seen for a one-month follow up evaluation.

There are no unpleasant or unusual procedures and no risks to your child. All techniques and procedures are standard in the field of speech pathology. If at any time, you wish to withdraw your child from this investigation, you may do so with no penalty. There is no monetary compensation for your child's participation. However, the results from this investigation should add information about the efficiency of certain training techniques, thus benefitting children in later treatment.

APPENDIX B: PARENTAL CONSENT FORM

APPENDIX B: PARENTAL CONSENT FORM

DEPARTMENT OF SPEECH LETTERHEAD

I, _____, the parent or legal guardian of _____, agree to his/her participation in a phonology training study by Lori Lee Stewart, MA, CCC-SLP and Alice Tanner Dyson, Ph.D., CCC-SP at the University of Florida Speech-Language and Hearing Clinic. I have been informed of the purpose and projected outcome of this study and agree to my child's participation. I am aware that I may withdraw my child from this study at any time and I have received a copy of the description of the study.

_____ _____

Signature of Parent or Guardian Date

_____ _____

Signature of Second Parent or Guardian Date

_____ _____

Signature of Researcher Date

_____ _____

Signature of Supervisor Date

APPENDIX C: WORD LIST FROM THE
ASSESSMENT OF PHONOLOGICAL PROCESSES - REVISED

APPENDIX C: ASSESSMENT OF PHONOLOGICAL PROCESSES - REVISED WORD LIST

Stimuli

1. baskit
2. boats
3. candle
4. chair
5. cowboy hat
6. crayons
7. three
8. black
9. green
10. yellow
11. feather
12. fish
13. flower
14. fork
15. glasses
16. glove
17. gum
18. hanger
19. horse
20. ice cubes
21. jumprope
22. leaf
23. mask
24. mouth
25. music box
26. nose
27. page
28. plane
29. queen
30. rock
31. Santa Claus
32. screwdriver
33. shoe
34. slide
35. smoke
36. snake
37. soap
38. spoon
39. square
40. star
41. string
42. sweater
43. television
44. thumb
45. toothbrush
46. truck
47. vase
48. watch
49. yo-yo
50. zipper

APPENDIX D: WORD LIST FOR GENERATIVE PHONOLOGICAL ASSESSMENT

APPENDIX D: WORD LIST FOR GENERATIVE PHONOLOGICAL ASSESSMENT

back
back-i
badge
badge-i
bite
biting
book
bookie
boot
bootie
bridge
bridge-i
brush
brushing
bus
bus-i
buzz
buzzing
cage
cage-i
cake
catch
catching
chair
chalk
cheese
cheese-i
chicken
chip
chip-i
coat
cob
comb
cool
cough
coughing
crash
crashing
cup
cup-i
cut
cutting
dress
dress-i
drive
driving
duck
ducky
eat
eating
face
fat
fatty
fire
fish
fishing
five
glove
glove-i
ice
icy
jail
jeep
jelly
juice
juicy
jump
key
kite
knife
knife-i
laugh
laughing
leaf
leafy
lip
mop
mouse
mousy
nail
noise
noisy
nose
nosy
orange
orange-i
page
page-i
paint
pants
peach
peachy
pie
pig
pill
pin
pinch
pinching
pool
pot
punch
punching
push
pushing
rock
rocky
roof
roof-i
rose
rosy
Santa
scarf
school
shampoo
shave
shaving
shirt
shoe
shovel
skate
ski
sky
sleep
sleeping
slip
small
snail
soap
soapy
sock
sock-i
soup
soupy
spider
spill
spin
spool
spot
stack
stairs
stick
stop
stove
stove-i
sun
swing
tack
tail
tear
teeth
toes
top
tub
vacuum
valentine
van
vanilla
vase
wash
washing
watch
watch-i
wave
waving
wing
zebra
Ziggy
zipper
zipping
zoo

APPENDIX E: WORD LIST FOR BASELINE MEASUREMENTS

APPENDIX E: WORD LIST FOR BASELINE MEASUREMENTS

brad
brag
braid
brain
brake
bran
brat
bread
break
brew
bribe
brick
bride
bright
brim
bring
broke
brown
chain
chair
chat
cheap
chew
chick
chin
chip
chop
fake
fall
fan
fat
feed
fight
food
four
fun
gee
gym
jab
jack
jar
jerk
Jill
joke
job
jump
phone
sack
sad
same
saw
say
scale
scat
school
scold
scooter
Scott
seat
sell
sent
shake
shape
shark
she
sheep
shine
ship
shoe
show
shut
sick
skate
skeleton
ski
skill
skillet
skin
skinny
skip
skirt
skunk
sky
slam
slap
sled
sleep
sleigh
slide
slip
slow
slug
sly
smack
small
smart
smear
smell
smile
smock
smog
smoke
smug
snack
snail
snake
snap
sneak
sneaky
snip
Snoopy
snow
snub
soap
spade
spank
speak
speck
speed
spell
spend
spike
spill
spin
spit
spoil
spoke
spook
spool
sport
spot
spy
stab
stack
stake
stamp
stand
star
start
state
stem
step
stew
stick
sting
stink
stir
stone
stop
store
van
vane
vat
verb
vet
Vic
vine
vote
vow
zany
zap
zebra
zero
zinc
zing
zip
zone
zoo
zoom

APPENDIX F
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 1

APPENDIX F: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 1

Subject 1

Pretraining phonological evaluation

Phonetic realizations of consonant singletons

Fricatives

f ---> b / # ____

[b]	food	[bud]
	fun	[bʌm]
	face	[bēɪs]
	fight	[bāɪt]
	fan	[bæm]

f ---> f / V ____ V
/ ____ #

v ---> b ~ bw / # ____

[b]	vote	[bōʊt]
	vat	[bæt]
	vet	[bɛt]
	vow	[bāʊ]
	vacuum	[bækʊm]
[bw]	vein	[bwēɪn], [bēɪn]
	verb	[bwɝd]
	vine	[bwāɪm]
	Vic	[bwɪk]

v ---> v ~ b / V ____ V
/ ____ #

[v]	driving	[dɹɑ̄ɪvɪŋ]
	waving	[wēɪvɪŋ]
	shaving	[ʃēɪvɪŋ]
	screwdriver	[swubwɑ̄ɪvɚ]
	stove-i	[tōʊ̄vi]
	drive	[dɹɑ̄ɪv]
	wave	[wēɪv]
	shave	[ʃēɪv]
	five	[bɑ̄ɪv]
	stove	[tōʊ̄v]
[b]	glove-i	[gwʌbi]
	shovel	[ʃʌbl̩]
	glove	[gwʌb] (2)

θ ---> b / # ____

[b]	thumb	[bʌm]

θ ---> f / ____ #

[f]	teeth	[tif]
	mouth	[mɑ̄ʊ̄f]

ð ---> d / # ____
/ V ____ V

[d]	they	[dēɪ]
	then	[dɛn]
	the	[də] (3)
	that	[dæt] (4)

		them	[dɛm] (2)
		feather	[bɛdɚ]
s ---> s	/ # ____ V ____ V ____ #		
z ---> z ~ s	/ # ____		
	[z]	zing	[zɪŋ]
		zone	[zo͞ʊn]
		zoom	[zum]
		zany	[ze͞ɪni]
		zip	[zɪp]
	[s]	zoo	[su], [zu]
		zipping	[sʊpɪŋ]
		Ziggy	[sɪdi]
		zipper	[sɪpɚ], [zɪpɚ]
		zinc	[sɪŋk]
z ---> z	/ V ____ V ____ #		
ʃ ---> ʃ	/ # ____ V ____ V ____ #		
ʒ ---> ʔ	/ V ____ V		
	[ʔ]	television	[tɛʔʃɪʔən]
h ---> ø ~ h	/ # ____		
	[ø]	hat	[æt]
		him	[ɪm]

	here	[ɪɚ]
	hanger	[æŋgl]
[h]	he	[hi]
	hurt	[hɝt]

Stops

p ---> p
/ # ____
/ V ____ V
/ ____ #

b ---> b
/ # ____
/ V ____ V
/ ____ #

t ---> t
/ # ____
/ ____ #

t ---> ʔ ~ t
/ V ____ V

[ʔ]	bootie	[buʔi]
	cutting	[kʌʔɪŋ]
	skeleton	[kɛlɪʔɪn]
[t]	fatty	[bæti]
	biting	[bāɪtɪŋ]

d ---> d
/ # ____
/ V ____ V
/ ____ #

k ---> k ~ g
/ # ____

[k]	key	[ki]
	cough	[kɔf]
	cool	[kul]

	cup	[kʌp]
	cut	[kʌt]
[g]	cake	[gēɪk]
	coat	[gōʊt]
	candle	[gænōʊ]
	cowboy	[gāʊbɔ̄ɪ]
	coughing	[gɔfɪŋ]

k ---> k / V ____ V
/ ____ #

g ---> g / # ____
/ ____ #

g ---> d / V ____ V

[d]	Ziggy	[sɪdi]

Affricates

ʧ ---> ʃ ~ ʧ / # ____
/ V ____ V

[ʃ]	chew	[ʃu]
	chain	[ʃēɪn]
	cheap	[ʃip]
	chick	[ʃɪk]
	chop	[ʃɑp]
	peachy	[piʃi]
[ʧ]	chin	[ʧɪn]
	catching	[kæʧɪŋ]
	watch-i	[wɑʧi]

ʧ ---> ʧ / ____ #

ʤ ---> ʃ ~ ʤ / # ___

[ʃ]	gee	[ʃi]
	jack	[ʃæk]
	joke	[ʃōūk]
	gym	[ʃɪm]
	jeep	[ʃip]
[ʤ]	juice	[ʤus]
	juicy	[ʤusɪ]
	jab	[ʤæg]
	just	[ʤɪs]

ʤ ---> ʤ / V ___ V
___ #

Nasals

m ---> m / # ___
___ #

n ---> n / # ___
___ #

n ---> n / V ___ V

[n]	skinny	[kɪni]
	zany	[zēɪni]

ŋ ---> ŋ / V ___ V
___ #

Liquids

l ---> w / # ____

[w]	look	[wʌk]
	lip	[wɪp]
	laugh	[wæf]
	leafy	[wifi]
	like	[wɑ̄ɪk]

l ---> l ~ d / V ____ V

[l]	valentine	[bæləndɑ̄ɪn]
	vanilla	[ʌʔələ]
	skeleton	[kɛlɪʔɪn]
	skillet	[kɪlɪt], [dɪlɪt]
[d]	jelly	[ʃɛdi]
	yellow	[ɛdo]

l ---> l / ____ #

r ---> w / # ____

[w]	roof	[wuf]
	rose	[wō͡ʊz]
	wrong	[wɔŋ]
	right	[wɑ̄ɪt]
	rocky	[wɑki]

r ---> ∅ / V ____ V

[∅]	zero	[zɪo]

Glides

w ---> w / # ____

w ---> d / V ___ V

[d]	flower	[plaʊ̄dɚ]

j ---> j ~ ∅ / # ___

[j]	you	[ju] (3)
	"yeah"	[jɔ], [jɛ̄ə], [jæ] (4)
[∅]	yo-yo	[o͞ʊjo͞ʊ]
	yellow	[ɛdo͞ʊ]

j ---> j / V ___ V

Phonetic realizations for consonant clusters

sp ---> p

[p]	spoon	[pun]
	spy	[pa͞ɪ]
	speak	[pik]
	spend	[pɛn]
	spider	[pa͞ɪdɚ]

st ---> t

[t]	stew	[tu]
	stone	[to͞ʊn]
	stove	[to͞ʊv]
	stir	[tɝ]
	stick	[tɪk]

sk ---> k

[k]	school	[kul] (3)
	skip	[kɪp]
	skin	[kɪn]

	scoot	[kut]
	skirt	[kɜ˞t]

sl ---> sw ~ s

[sw]	sleep	[swɪp] (3)
	slip	[swɪp]
	slow	[swo͞u] (3)
	slug	[swʌg]
	slide	[swa͞ɪd] (2)
[s]	sleigh	[se͞ɪ]
	slam	[sæm]
	sled	[sɛd]

sn ---> n ~ b ~ ø

[n]	snail	[ne͞ɪl] (2)
	snakes	[ne͞ɪks]
[b]	snack	[bæk]
	snow	[bo͞u]
[ø]	sneak	[ɪŋk]
	snip	[ɪp]

sm ---> m ~ b

[m]	smell	[mɛl] (2)
	smog	[mɑg]
	small	[mɑl] (2)
	smile	[ma͞ɪl]
	smoke	[mo͞uk], [bo͞uk]
[b]	smack	[bæk]
	smock	[bɑk]

	smug	[bʌg]
	smear	[bɪ̄ɚ̄]

br ---> bw ~ br

[bw]	brick	[bwɪk]
	brew	[bwu]
	brush	[bwʌʃ]
	bread	[bwɛd]
	bring	[bwɪŋ]
[br]	break	[brēɪk] (2)

Follow-up phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> sp ~ b ~ p / # ___

[sp]	for	[spɔ̄ɚ̄]
	fight	[spāɪt]
	feed	[spid]
	food	[spud]
	phone	[spōūn]
[b]	face	[bēɪs]
	fall	[bɔl]
	five	[bāɪv]
	fatty	[bæti]
	fishing	[bɪʃɪŋ]
[p]	fan	[pæn]
	fun	[pʌn]
	fell	[pɛl]

f ---> f / V ____ V
/ ____ #

v ---> sp ~ b / # ____

[sp]	vane	[spēɪn]
	vote	[spōʊt]
	van	[spæn]
	vow	[spāʊ]
	Vic	[spɪk]
[b]	vacuum	[bækʊm]
	valentine	[bæ̃tāɪn]

v ---> v / V ____ V

v ---> v / ____ #

[v]	drive	[ʃrāɪv]
	wave	[wēɪv]
	stove	[tōʊv]
	shave	[ʃēɪv]
	five	[bāɪv]

θ ---> b / # ____

[b]	thumb	[bʌm]

θ ---> f ~ t / ____ #

[f]	teeth	[tiːf]
	mouth	[māʊf]
[t]	with	[wɪt]

ð ---> d / # ____
/ V ____ V

[d]	the	[də] (4)

this [dɪs] (15)

these [diz] (6)

feather [bɛdɚ]

another [ənʌdɚ]

s ---> s / # ____ ; V ____ V ; ____ #

z ---> z / # ____ ; V ____ V ; ____ #

z ---> sw / # ____ p

[sw] zip [swɪp]

zipper [swɪpɚ], [zɪpɚ]

zipping [swɪpɪŋ]

ʃ ---> ʃ / # ____ ; V ____ V ; ____ #

ʒ ---> ʃ / V ____ V

[ʃ] television [tɛləɪʃən]

h ---> h / # ____

Stops

p ---> p / # ____ ; V ____ V ; ____ #

b ---> b / # ____ ; V ____ V ; ____ #

t ---> t / # ____

[t]	tail	[tēɪl]
	teeth	[tiːf]
	top	[tɑp]
	tub	[tʌb]
	to	[tu]

t ---> t / V ____ V

t ---> t ~ k / ____ #

[t]	eat	[iːt]
	shirt	[ʃɝt]
	pot	[pɑt]
	shut	[ʃʌt]
	hat	[hæt]
[k]	smart	[smɑ̄ɝk]
	sport	[spɔ̄ɝk]
	start	[stɑ̄ɝk]
	state	[stēɪk]
	vote	[spōʊ̄k]

d ---> d / # ____

[d]	ducky	[dʌkiː]
	didn't	[dɪnt]
	down	[dɑ̄ʊ̄n]
	do	[dɪ], [du] (2)

d ---> d / V ____ V
/ ____ #

k ---> k / # ____
/ V ____ V
/ ____ #

g ---> g / # ____
/ V ____ V
/ ____ #

Affricates

ʧ ---> ʃ ~ ʧ / # ____
/ V ____ V
/ ____ #

[ʃ]	chew	[ʃu]
	chop	[ʃap]
	chin	[ʃɪn]
	chalk	[ʃɔk]
	cheese	[ʃiz]
	watch-i	[waʃi]
	watch	[waʧ], [waʃ]
[ʧ]	chain	[ʧēin]
	catching	[kæʧɪŋ]
	peachy	[piʧi]
	catch	[kæʧ]

peach [pitʃ]

watch [watʃ], [waʃ]

ʧ ---> ʃ ~ ʧ / # ___

[ʃ] juice [ʃus]

jail [ʃēil]

gee [ʃi]

jar [ʃār]

job [ʃab]

[ʧ] juicy [ʧusi]

ʤ ---> ʤ ~ ʧ / V ___ V
___ #

[ʤ] page-i [pēiʤi]

badge-i [bæʤi]

cage-i [kēiʤi]

page [pēiʤ] (2)

badge [bæʤ]

cage [kēiʤ]

The examples presented below appear to represent a morpheme-specific rule involving the base bridge.

[ʧ] bridge-i [bwiʧi]

bridge [bwiʧ]

Nasals

m ---> m / # ___
V ___ V
___ #

n ---> n / # ____ ; V ____ V ; ____ #

ŋ ---> ŋ / V ____ V ; ____ #

Liquids

l ---> w / # ____

[w]	laugh	[wæf]
	leafy	[wɪfi]
	lips	[wɪps]
	lid	[wɪd]
	like	[wāɪk] (4)

l ---> l / V ____ V ; ____ #

[l]	jelly	[ʃɛli]
	vanilla	[ənɪlo]
	yellow	[jɛlōʊ]
	television	[tɛləɪʃən]
	skeleton	[kɛləɪn]
	pull	[pul]
	jail	[ʃēɪl]
	sell	[sɛl]
	fall	[fɔl]
	shovel	[ʃʌvl̩]

r ---> w~ r / # ____

[w]	roof	[wuf]

		rose	[wōʊ̄z]
		rocky	[waki]
		roof-i	[wufi]
		rock	[wak] (2)
	[r]	rosy	[rōʊ̄zi]
		real	[ril]

r ---> ø / V ____ V

[ø]	zero	[zio]

Glides

w ---> w / # ____

w ---> d / V ____ V

[d]	flower	[pwāʊ̄dɚ]

j ---> j ~ ø / # ____

[j]	yellow	[jɛlo]
	"yeah"	[jæ] (2), [jɛ̄ə]
[ø]	yo-yo	[ōʊ̄jōʊ̄]

j ---> j / V ____ V

Phonetic realizations for consonant clusters

sp ---> sp ~ p

[sp]	spend	[spɛnd]
	spool	[spul] (2)
	spike	[spāɪ̄k]
	spoke	[spōʊ̄k]
	spank	[spæŋk]
[p]	spoon	[pun] (2)
	spider	[pāɪ̄dɚ]

	spell	[pɛl]
	speak	[pik]
	spoil	[pɔ̄il]

st ---> st ~ t

[st]	store	[stɔ̄ɹ]
	stone	[stō͡ʊn]
	stand	[stæn]
	stake	[stēik]
	sting	[stɪŋ]
[t]	stove	[tō͡ʊv]
	stem	[tɛm]
	stir	[tɝ] (2)
	stuff	[tʌf]
	step	[tɛp]

sk ---> sk ~ k

[sk]	skunk	[skʌŋk]
	skip	[skɪp]
	skinny	[skɪni]
	ski	[ski] (2)
	skill	[skɪl]
[k]	skirt	[kɝt]
	sky	[kāi] (2)
	skeleton	[kɛləɪn]
	skin	[kɪn]
	scarf	[kɑ̄ɹf]

sl ---> sl ~ sw ~ s

[sl]	slow	[slo͞u]
	slug	[slʌg]
	slip	[slɪp], [sɪp]
[sw]	sleeping	[swipɪŋ]
	slide	[swa͞id] (2)
	sloppy	[swɑpi]
	sly	[swa͞ɪ]
	sleep	[swip] (2), [slip]
[s]	sled	[sɛd]
	slam	[sæm]
	sleigh	[se͞ɪ]
	slap	[sæp]

sn ---> sn

[sn]	snip	[snɪp]
	snap	[snæp]
	snow	[sno͞u]
	sneak	[snik]
	snail	[sne͞ɪl] (2)

sm ---> sm ~ m

[sm]	smell	[smɛl] (2)
	smoke	[smo͞uk] (2)
	smart	[sma͞ɚk]
	smile	[sma͞ɪl] (2)
	smear	[smɪ͞ɚ]

[m]	smog	[mɑg]
	smock	[mɑk]

br ---> bw ~ br ~ spw

[bw]	brew	[bwu]
	brush	[bwʌʃ]
	bread	[bwɛd]
	bright	[bwa͡ɪt]
	broke	[bwo͡ʊk]
[br]	bring	[brɪŋ]
	brick	[brɪk]
[spw]	brim	[spwɪm]
	brown	[spwa͡ʊn]

APPENDIX G
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 2

APPENDIX G: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 2

Subject 2

Pretraining phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> f ~ fw / # ____

[f]	fight	[fa͡ɪ]
	fish	[fɪ]
	fun	[fʌ]
	food	[fu]
	phone	[fo͡ʊ]
[fw]	feed	[fwi]
	face	[fwe͡ɪ]

f ---> w / V ____ V

[w]	coughing	[kɔwɪ]
	knife-i	[na͡ɪwɪ]
	laughing	[læwɪ]
	leafy	[liwi]
	roof-i	[wuwi]

f ---> ø / ____ #

[ø]	cough	[kɔ]
	knife	[na͡ɪ]
	laugh	[læ]
	leaf	[li]
	roof	[wu]

v ---> v ~ w ~ bw ~ f / # ____

[v]	valentine	[væjətāɪ]
	vein	[vēɪ]
	verb	[vɝ]
	Vic	[vɪ]
	vote	[vōʊ]
[w]	vase	[vēɪ], [wēɪx]
	vow	[wāʊ]
	vat	[wæx]
[bw]	vacuum	[bwēɪkʊ]
	vine	[bwāɪ]
[f]	vanilla	[fəlēɪə]
	vet	[fɛ]

v ---> w ~ v / V ____ V

[w]	shaving	[ʃēɪwɪ]
	glove-i	[glʊwɪ]
	waving	[wēɪwɪ]
	stove-i	[tōʊwɪ]
	driving	[drāɪwɪ]
[v]	screwdriver	[kudrāɪvɝ]

v ---> ∅ / ____ #

[∅]	shave	[ʃēɪ]
	glove	[glʊ], [glʌ]
	wave	[wēɪ]
	stove	[tōʊ]
	drive	[drāɪ]

θ ---> ʧ / # ____

[ʧ]	thumb	[tʃʌwə]

θ ---> ø / V ____ V

[ø]	toothbrush	[tubʌ]

θ ---> ʔ ~ ø / ____ #

[ʔ]	with	[wɪʔ]
[ø]	teeth	[tiː]

ð ---> d ~ ð / # ____

[d]	they	[dēɪ]
[d ~ ð]	this	[dɪʔ] (11), [dɪ] (2), [ðɪʔ], [ðɪ],

ð ---> w / V ____ V

[w]	feather	[fɛwɚ]

s ---> s ~ ʃ / # ____

[s]	Santa	[sæ̃ɪ], [sæn]
	sock-i	[saki]
	sun	[sʌ]
	sick	[sɪk]
	see	[siː]
[ʃ]	soup	[ʃu]
	sock	[ʃɑ]
	sad	[ʃæ]
	same	[ʃēɪ]
	say	[ʃēɪ]

s ---> w / V ____ V

	[w]	juicy	[ʤuwɪ]
		glasses	[glǣʊ̄wɪ]

s ---> ʔ ~ ∅ / ___ #

[ʔ]	this	[dɪ] (2), [dɪʔ] (11)
[∅]	bus	[bʌ]
	juice	[ʤu]
	mouse	[mǣʊ̄]

z ---> z ~ ʒ ~ ʤ / # ___

[z]	zipping	[zɪpwɪ]
	Ziggy	[zɪgi]
	zero	[zɪwo]
	zipper	[zɪpɚ], [zɪwɚ]
	zebra	[zɪbwə], [tɪbwə]
[ʒ]	zoo	[ʒu] (2)
	zip	[ʒɪ]
	zone	[ʒo͡ʊ̄n]
	zing	[ʒɪ̃]
[ʤ]	zap	[ʤæ]
	zoom	[ʤu]
	zinc	[ʤɪ]

z ---> w / V ___ V

[w]	cheesy	[ʧi wɪ]
	nosy	[no͡ʊ̄wɪ]
	bus-i	[bʌwɪ]

z ---> ∅ / ___ #

[∅]	buzz	[bʌ]

		noise	[nɔ̄ɪ]
		rose	[wōʊ̄]
		stairs	[tɛ̄ə̄]
		toes	[tōʊ̄]
ʃ ---> ʃ	/ # ___		
ʃ ---> w ~ ø	/ V ___ V		
	[w]	fishing	[fɪwɪ]
	[ø]	brushing	[bʌɪ]
ʃ ---> ø ~ ʔ	/ ___ #		
	[ø]	fish	[fɪ] (2)
		wash	[wɑ]
		brush	[bwʌ]
		crash	[kwēɪ]
		toothbrush	[tubʌ]
	[ʔ]	push	[pʊʔ]
ʒ ---> w	/ V ___ V		
	[w]	television	[tɛləwɪwɪ]
h ---> h	/ # ___		

Stops

p ---> p	/ # ___		
p ---> w	/ V ___ V		
	[w]	soupy	[ʃuwɪ]
		Snoopy	[ʃuwɪ]
		soapy	[ʃōʊ̄wɪ]
p ---> ø ~ p	/ ___ #		
	[ø]	cup	[kʌ]

		jeep	[ʤi]
		mop	[ma]
		soup	[ʃu]
		chip	[ʧɪ], [ʧɪp]
	[p]	soap	[sōʊp], [ʃōʊ] (2)
		jump rope	[ʤʌmwōʊp]
		chip	[ʧɪ], [ʧɪp]

b ---> b / # ____
/ V ____ V

b ---> ø / ____ #

	[ø]	cob	[ka]
		tub	[tʌ]
		snub	[ʃʌ]
		stab	[tæ]
		job	[ʤa]

t ---> t / # ____

t ---> w ~ t / V ____ V

	[w]	later	[lēɪwø]
		cutting	[kʌwɪ]
		fatty	[fæwɪ]
		biting	[bāɪwɪ]
		skating	[kēɪwɪ]
		skeleton	[kɛkɪtɪn]

t ---> ø ~ ʔ ~ x / ____ #

	[ø]	fight	[fāɪ]
		eat	[i]

		vote	[vo͞ʊ]
		boot	[bu]
		cut	[kʌ]
	[ʔ]	got	[gɑʔ] (2)
		put	[pʊʔ]
	[x]	vat	[wæx]
		shut	[ʃʌx]
d ---> d	/	# ____	
d ---> w	/	V ____ V	
	[w]	spider	[pa͞iwɚ]
		scooter	[kuwɚ]
d ---> ø	/	____ #	
	[ø]	sad	[ʃæ]
		sled	[ʃɛ͞ə]
		spade	[pe͞i]
		speed	[pi]
		feed	[fwi]
k ---> k	/	# ____	
	/	V ____ V	
k ---> ø ~ ʔ ~ k ~ x			/ ____ #
	[ø]	duck	[dʌ]
		tack	[tæ]
		cake	[ke͞i]
		Vic	[vɪ]
		book	[bʌ]
	[ʔ]	fake	[fe͞iʔ]

	smack	[f æʔ]
	spoke	[pōūʔ]
	speck	[p ɛʔ]
	sneak	[s iʔ]
[k]	sick	[s ɪk]
	rock	[wɑk] (2)
	black	[blēɪk]
[x]	back	[bæx]
	shake	[ʃēɪ x]
	snake	[ʃēɪ x], [ʃēɪ]

g ---> g / # ____ ; V ____ V

g ---> ∅ / ____ #

[∅]	pig	[p ɪ]
	smug	[f ʌ]
	smog	[f ɑ]
	brad	[bwæ]
	slug	[s̲l ʌ]

Affricates

ʧ ---> ʧ / # ____ ; V ____ V

ʧ ---> ∅ / ____ #

[∅]	catch	[k æ]
	peach	[p i]

ʤ ---> ʤ / # ____

ʤ ---> ʤ ~ ʃ ~ w ~ ∅ / V ____ V

	[ʤ]	cage-i	[kēɪ ʤɪ]
	[ʃ]	page-i	[pēɪ ʃɪ]
	[w]	bridge-i	[bwɪ wɪ]
	[Ø]	badge-i	[bæɪ]
ʤ ---> Ø	/ ____ #		
	[Ø]	cage	[kēɪ]
		page	[pēɪ] (2)
		bridge	[bwɪ]
		badge	[bēɪ]

Nasals

m ---> m	/ # ____		
m ---> Ø	/ ____ #		
	[Ø]	comb	[kōʊ]
		same	[ʃēɪ]
		zoom	[ʤu]
		gum	[gʌ]
		I'm	[āɪ]
n ---> n	/ # ____		
n ---> w	/ V ____ V		
	[w]	skinny	[kɪ wɪ]
		zany	[ʃēɪ wɪ]
n ---> Ø ~ n	/ ____ #		
	[Ø]	pin	[pɪ]
		sun	[sʌ]
		phone	[fōʊ]
		shine	[ʃāɪ]

	stone	[tōʊ]
[n]	queen	[kwin]
	plane	[plēɪn]
	brown	[fwāʊn]
	zone	[zōʊn]
	one	[wʌn] (2)

ŋ ---> w / V ___ V

[w]	hanger	[hæwɚ]

ŋ ---> ø ~ ŋ ~ n / ___ #

[ø]	wing	[wɪ]
	string	[trɪ]
	washing	[waɪ]
	shaving	[ʃēɪ wɪ]
	fishing	[fɪwɪ]
[ŋ]	sting	[tɪŋ]
[n]	going	[gʌn]

Liquids

l ---> l / # ___

l ---> l ~ w ~ j / V ___ V

[l]	yellow	[alōʊ]
	television	[tɛləwɪwɪ]
	skillet	[kɪlɪ], [kɪwɪ]
[w]	jelly	[ʤɛwɪ]
[j]	valentine	[væjətāɪ]

l ---> l ~ V ~ ø / ___ #

[l]	tail	[tēɪl]

	school	[kul] (4)
	nail	[nēɪl]
	pill	[pɪl]
	pull	[pul]
[V]	sell	[ʃæə]
	skill	[kɪə]
	shovel	[ʃʌwo]
	candle	[kænо]
	spoil	[pɔɪə]
[ø]	small	[fɑ] (2)
	fall	[fɑ]
	Jill	[ʤɪ]
	all	[ɑ]
	hole	[hōʊ]

r ---> w / # ____
V ____ V

[w]	roof	[wu]
	rose	[wōʊ]
	rocky	[wakɪ]
	rosy	[wōʊkɪ]
	right	[wɑɪʔ]
	zero	[zɪwo]
	cherry	[ʧɛwɪ] (2)

Glides

w ---> w / # ____
V ____ V

j ---> j ~ w ~ ∅ / # ___

[j]	"yeah"	[jɛ]
	you	[ju]
[w]	yo-yo	[wo͞uwo͞u]
[∅]	yellow	[ɑlo͞u]

j ---> w / V ___ V

[w]	yo-yo	[wo͞uwo͞u]

Phonetic realizations of consonant clusters

sp ---> p

[p]	speak	[pi]
	spade	[pe͞ɪ]
	spook	[pu]
	sport	[pɔ͞ɪ]
	speck	[pɛʔ]

st ---> t

[t]	sting	[tɪŋ]
	state	[te͞ɪ]
	stab	[tæ]
	stew	[tu]
	start	[tɑ]

sk ---> k

[k]	skip	[kɪ]
	scat	[kæ]
	scoot	[ku]
	scarf	[kɑ]
	skunk	[kʌ]

sl ---> s̲l ~ sl ~ ʃ ~ sw

[s̲l]	sleep	[s̲li] (2)
	sleeping	[s̲liwi] (2)
	sly	[s̲lɑ̄ɪ]
	sleigh	[s̲lē]
	sloppy	[s̲lɑwɪ]
[sl]	slide	[slɑ̄ɪ] (2)
[ʃ]	slam	[ʃæə]
	sled	[ʃɛ̄ə]
[sw]	slip	[swɪ], [slɪ]

sn ---> ʃ ~ s

[ʃ]	snakes	[ʃē]
	snap	[ʃæ]
	Snoopy	[ʃuwi]
	snow	[ʃō]
	snub	[ʃʌ]
[s]	sneaky	[siwi]
	sneak	[si?]
	snack	[sæ?], [ʃæ]

sm ---> f ~ ʃ ~ m

[f]	smog	[fɑ]
	smart	[fɑ]
	smug	[fʌ]
	smack	[fæ?]
	smear	[fɪ̄ə]
[ʃ]	smile	[ʃɑ̄ɪwl̩], [fɑ̄ɪwl̩]

	smock	[ʃɑ]
[m]	smell	[mɛl], [fɛ̄ə]

br ---> bw ~ br

[bw]	brew	[bwu]
	broke	[bwōʊ̄]
	brush	[bwʌ]
	bread	[bwɛ̄ə]
	bridge	[bwɪ]
[br]	brick	[brɪ]

Follow-up phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> f / # ____

f ---> w / V ____ V

[w]	knife-i	[nɑ̄ɪwɪ]
	laughing	[læwɪ]
	leafy	[liwi]

f ---> ø / ____ #

[ø]	scarf	[kɑ]
	cough	[kɔ]
	knife	[nɑ̄ɪ]
	laugh	[læ]
	leaf	[li] (2)

v ---> v / # ____

v ---> w ~ v / V ____ V

[w]	driving	[drɑ̄ɪwɪ]

		screwdriver	[krudrɑ̄ɪwɚ]
		television	[tɛləwɪʃən]
		oven	[əwɪ]
		glove-i	[glʌwɪ]
		waving	[fwēɪvɪ]
		shaving	[ʃēɪvɪ]
v ---> ∅	/	____ #	
	[∅]	drive	[drɑ̄ɪ]
		wave	[wēɪ]
		five	[fɑ̄ɪ]
		glove	[glʌ] (2)
		shave	[ʃēɪ]
θ ---> θ	/	# ____	
θ ---> ∅	/	____ #	
	[∅]	teeth	[tɪ]
		mouth	[mɑ̄ʊ]
ð ---> ð ~ d	/	# ____	
	[ð]	that	[ðæ]
		these	[ðɪ], [dɪ]
		this	[ðɪʔ] (9), [dɪʔ]
	[d]	the	[dɪ]
		there	[dɛ̄ɚ]
ð ---> ʒ	/	V ____ V	
	[ʒ]	feather	[fɛʒɚ]
s ---> s	/	# ____	
	[s]	sun	[sʌ]

		sad	[sæ]
		sell	[sɛl]
		sick	[sɪʔ]
		say	[sēɪ]
	[ʃ]	sock	[ʃɑk]
		soup	[ʃu]
		saw	[ʃɔ]
		seat	[ʃi]
		soapy	[ʃōūpi]

s ---> w ~ s ~ z ~ ʃ ~ b / V ____ V

[w]	juicy	[ʤuwɪ]
	glasses	[glæwɪ]
[s]	icy	[āɪsɪ]
[z]	mousy	[māūzɪ]
[ʃ]	bus-i	[bʌʃɪ]
[b]	dressy	[drɛbɪ]

s ---> ø / ____ #

[ø]	bus	[bʌ]
	juice	[ʤu]
	ice	[āɪ]
	horse	[hɔ]
	vase	[vēɪ], [vēɪʔ]

z ---> z ~ ʒ / # ____

[z]	zipping	[zɪpɪ]
	zap	[zæ]
	zing	[zɪŋ]

	zone	[zōʊ̄n]
	zip	[zɪ]
[ʒ]	zoom	[ʒu]
	zoo	[ʒu] (2)

z ---> w ~ z ~ ʒ / V ___ V

[w]	noisy	[nɔ̄ɪ̄wɪ]
	rosy	[wōʊ̄wɪ]
[z]	nosy	[nōʊ̄zɪ]
	music box	[mjuzɪkbaks]
[ʒ]	buzzing	[bʌʒɪ]

z ---> ∅ / ___ #

[∅]	noise	[nɔ̄ɪ̄]
	rose	[wōʊ̄]
	nose	[nōʊ̄] (2)
	buzz	[bʌ]
	cheese	[tʃi]

ʃ ---> ʃ / # ___

ʃ ---> ʃ ~ w / V ___ V

[ʃ]	brushing	[bwʌʃɪ]
	fishing	[fɪʃɪ]
	crashing	[kræʃɪ]
	washing	[ʃwɑʃɪ]
[w]	pushing	[pʊwɪ]

ʃ ---> ∅ / ___ #

[∅]	brush	[bwʌ]
	fish	[fɪ] (2)

		crash	[kwēɪ]
		wash	[ᵛwɑ]
		push	[pʊ]
ʒ ---> ʃ	/ V ___ V		
	[ʃ]	television	[tɛʃə wɪʃən]
h ---> h	/# ___		

Stops

p ---> p	/# ___		
p ---> p ~ b	/ V ___ V		
	[p]	chip-i	[ʧɪ pɪ]
		soapy	[sōʊpɪ]
		zipping	[zɪpɪ]
	[b]	cup-i	[kʌbɪ]
		sloppy	[slɑbi]
		zipper	[zɪbɚ], [zɪbə]
p ---> ø ~ ʔ ~ p	/ ___ #		
	[ø]	soup	[ʃu]
		cup	[kʌ]
		jeep	[ʤi]
		lip	[lɪ]
		mop	[mɑ]
	[ʔ]	chop	[tɑʔ]
		ship	[ʃɪʔ]
		snip	[ʃɪʔ]
		step	[tɛʔ]
		keep	[kiʔ], [ki] (5)

	[p]	stop	[staɒp] (2), [staʔ]
		slip	[slɪp], [slɪ]
		sheep	[ʃip]
		snap	[næp]
		jump rope	[ʤʌwōūp]
b ---> b	/	# ____	
	/	V ____ V	
b ---> ø	/	____ #	
	[ø]	cob	[kɑ]
		tub	[tʌ]
		verb	[vɝ]
		job	[ʤɑ]
		jab	[ʤæ]
t ---> t	/	# ____	
t ---> w	/	V ____ V	
	[w]	eating	[iwɪ]
		cutting	[kʌwɪ]
		fatty	[fæwɪ]
		biting	[bāɪwɪ]
t ---> ø ~ ʔ	/	____ #	
	[ø]	boot	[bu]
		cut	[kʌ]
		spit	[pɪ]
		pot	[pɑ]
		shut	[ʃʌ]
	[ʔ]	brat	[bwæʔ]

		right	[wāɪʔ]
		put	[pʊʔ] (3)
		eat	[iʔ] (2)
		it	[ɪʔ] (3)
d ---> d	/ # ___		
d ---> d	/ V ___ V		
	[d]	spider	[pāɪdɚ]
d ---> ø	/ ___ #		
	[ø]	feed	[fi]
		need	[ni]
		sled	[slɛ̄ə]
		bread	[bwɛ]
		speed	[pi]
k ---> k	/ # ___		
k ---> k ~ g	/ V ___ V		
	[k]	okay	[okē ɪ] (2)
		sock-i	[ʃakɪ]
		sneaky	[sikɪ]
		cookie	[kʊkɪ]
	[g]	bookie	[bʊgɪ]
		ducky	[dʌgɪ]
		rocky	[wagɪ]
k ---> ø ~ ʔ ~ k		/ ___ #	
	[ø]	back	[bæ]
		book	[bʊ]
		duck	[dʌ]

	fake	[fēɪ]
	sack	[sæ]
[ʔ]	cake	[kēɪʔ]
	chalk	[ʧɔʔ]
	jack	[ʤæʔ]
	sick	[sɪʔ]
	truck	[trʌʔ]
[k]	snack	[næk], [ʃæk]
	sock	[ʃak]

g ---> g / # ____
V ____ V

g ---> ø / ____ #

[ø]	pig	[pɪ]
	smog	[ma]
	egg	[ēɪ]
	dog	[da], [du]
	brag	[bræ]

Affricates

ʧ ---> ʧ / # ____

ʧ ---> ʧ ~ g ~ ʃ / V ____ V

[ʧ]	peachy	[piʧi]
[g]	watch-i	[wagi]
[ʃ]	catching	[kæʃi]

ʧ ---> ø ~ ʔ / ____ #

[ø]	peach	[pi]
	watch	[wa], [waʔ]

[ʔ]	catch	[kæʔ]

ʤ ---> ʤ / # ___

ʤ ---> ʤ ~ ʒ / V ___ V

[ʤ]	page-i	[pēɪʤi]
	cage	[kēɪʤi]
[ʒ]	bridge-i	[bwɪʒi]

ʤ ---> ∅ / ___ #

[∅]	page	[pēɪ] (2)
	badge	[bæ]
	cage	[kēɪ]
	bridge	[bwɪ]

Nasals

m ---> m / # ___

/ V ___ V

m ---> ∅ ~ m / ___ #

[∅]	comb	[kōʊ]
	same	[sēɪ]
	zoom	[ʒu]
	gum	[gʌ]
	vacuum	[væʒu]
[m]	thumb	[θʌm]
	gym	[ʤɪm]
	slam	[slæm]
	brim	[bwɪm]

n ---> n / # ___

n ---> n ~ w / V ___ V

	[n]	vanilla	[vənɪdə]
	[w]	skinny	[kɪwɪ]
n --->	n ~ ø	/ ____ #	
	[n]	in	[ɪn] (2)
		zone	[zo͞ʊ͞n]
		bran	[bræn]
		phone	[fo͞ʊ͞n]
		shine	[ʃa͞ɪn]
	[ø]	vine	[va͞ɪ]
		sun	[sʌ]
		fan	[fæ]
		chain	[tʃe͞ɪ]
		skin	[kɪ]
ŋ --->	ŋ	/ V ____ V	
	[ŋ]	hanger	[hæŋɚ]
ŋ --->	ø	/ ____ #	
	[ø]	wing	[wɪ]
		pushing	[pʊwɪ]
		eating	[ɪwɪ]
		cutting	[kʌwɪ]
		buzzing	[bʌʒɪ]

Liquids

l --->	l	/ # ____	
	[l]	laugh	[læ]
		lip	[lɪ]
		leafy	[lɪwɪ]

		laughing	[l æ w ɪ]
l ---> l	/ V ___ V		
	[l]	valentine	[v æ l ə t ā ɪ]
		jelly	[ʤ ɛ l ɪ]
		skillet	[k ɪ l ɪ], [k ɪ]
		yellow	[a l ō ʊ]
		skeleton	[k ɛ l ə t ɪ ə]
l ---> l ~ ∅	/ ___ #		
	[l]	jail	[ʤ ē ɪ l]
		nail	[n ē ɪ l]
		pill	[p ɪ l]
		sell	[s ɛ l]
		Jill	[ʤ ɪ l]
	[∅]	pull	[p u]
		fall	[f ɑ]
		small	[m ɑ], [m ɔ]
		school	[k u] (4)
r ---> w	/ # ___ V ___ V		
	[w]	rose	[w ō ʊ]
		rocky	[w ɑ g i]
		roof-i	[w u k i]
		right	[w ā ɪ ʔ]
		ready	[w ɛ w i]
		zero	[z i w o]
		Lori	[l ɔ w ɪ]

Glides

w ---> w / # ___
/ V ___ V

j ---> j ~ ʤ ~ ø / # ___

[j]	"yeah"	[jæ]
	you	[ju] (2)
[ʤ]	yo-yo	[ʤo͞uʤo͞u]
[ø]	yellow	[alo͞u]

j ---> ʤ / V ___ V

[ʤ]	yo-yo	[ʤo͞uʤo͞u]

Phonetic realization of consonant clusters

sp ---> p ~ sp

[p]	speak	[pi]
	spin	[pɪ] (2)
	spell	[pɛl] (2)
	spy	[pa͞ɪ]
	spook	[pu]
[sp]	spool	[spul], [pu]
	sport	[spɔ]

st ---> st ~ t

[st]	stem	[stɛ͞ə]
	state	[ste͞ɪ]
	stamp	[stæʔ]
	stop	[stap] (2), [staʔ]
	star	[sta], [ta] (2)
[t]	sting	[tɪ̃]

	step	[tɛʔ]
	stab	[tæ]
	stew	[tu]
	start	[tɑ]

sk ---> k ~ sk

[k]	ski	[kɪ] (2)
	skin	[kɪn]
	scale	[kēɪl]
	scat	[kæ]
	skirt	[kɝ]
[sk]	skunk	[skʌ]
	skinny	[skɪwɪ]

sl ---> sl

[sl]	sled	[slɛ̄ə̄]
	slug	[slʌ]
	sloppy	[slɑbɪ]
	slow	[slō͡ʊ]
	slide	[slɑ̄ɪ] (2)

sn ---> n ~ ʃ ~ s ~ sn

[n]	snake	[nēɪ], [ʃēɪʔ]
	snack	[næʔ], [ʃæk]
	snap	[næp]
	snow	[nō͡ʊ]
	snub	[nʌ]
[ʃ]	snip	[ʃɪʔ]
	snakes	[ʃēɪʔ]

	Snoopy	[ʃukɨ]
[s]	sneaky	[sɨkɨ]
	sneak	[sɪʔ]
[sn]	snail	[snēɪʊ], [ʃēɪl]

sm ---> m ~ sm

[m]	smell	[mɛl] (2)
	smack	[mæʔ]
	smart	[mɑ]
	smock	[mɑ]
	small	[mɑ] (2)
[sm]	smile	[smāɪwɻ]

br ---> br ~ bw

[br]	break	[brēɪ]
	braid	[brēɪ] (2)
	brag	[bræ]
	brad	[bræ]
	bribe	[brāɪ]
[bw]	brim	[bwɪm]
	brush	[bwʌ]
	broke	[bwōʊ]
	brew	[bwu]
	brown	[bwāʊn]

APPENDIX H
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 3

APPENDIX H: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 3

Subject 3

Pretraining phonological evaluation

Phonetic realizations of consonant singletons

Fricatives

f ---> f / # ____ ; V ____ V ; ____ #

v ---> v / # ____ ; V ____ V ; ____ #

θ ---> g / # ____

[g] thumb [gʌm]

θ ---> f ~ θ / ____ #

[f] mouth [maʊf]

with [wɪf]

[θ] tooth [tuθ]

ð ---> d / # ____

[d] there's [dɛ̃ɚz] (4)

this [dɪs] (7)

these [diz], [ðiz]

ð ---> d / V ____ V

[d] feather [fɛdɚ]

s ---> s / # ____ ; V ____ V ; ____ #

z ---> z / # ____ ; V ____ V ; ____ #

ʃ ---> ʃ ~ s / # ____ ; V ____ V ; ____ #

[ʃ]	shoe	[ʃu] (3)
	shave	[ʃēɪv]
	shirt	[ʃɝt]
	ship	[ʃɪp]
	shine	[ʃāɪn]
	brushing	[brʌʃɪŋ]
	brush	[brʌʃ]
	toothbrush	[tusbwʌʃ]
[s]	she	[si]
	sheep	[sip]
	shut	[sʌt]
	shark	[sāɚk]
	show	[sōū]
	fishing	[fɪsɪŋ]
	pushing	[pʊsɪŋ]
	crashing	[kræsɪŋ]
	washing	[wasɪŋ]
	fish	[fɪs]
	push	[pɪs]

wash [wɑs]

crash [kræs]

ʒ ---> ʒ

h ---> h

/ V ____ V

/ # ____

Stops

p ---> p

b ---> b

t ---> t

d ---> d

k ---> k

g ---> g

/ # ____

/ V ____ V

/ ____ #

Affricates

tʃ ---> tʃ

/ # ____
/ V ____ V
/ ____ #

dʒ ---> dʒ

/ # ____
/ V ____ V
/ ____ #

Nasals

m ---> m

/ # ____
/ V ____ V
/ ____ #

n ---> n

/ # ____
/ V ____ V
/ ____ #

ŋ ---> ŋ

/ V ____ V
/ ____ #

Liquids

l ---> w

/ # ____

[w]

laugh	[wæf]
lip	[wɪp]
little	[wɪtl̩]
leafy	[wi̯fi]
laughing	[wæfɪŋ]

l ---> l

/ V ____ V

r ---> r

/ # ____
/ V ____ V

Glides

w ---> w / # ____ ; V ____ V

j ---> j / # ____ ; V ____ V

Phonetic realizations for consonant clusters

sp ---> p

[p]	speak	[pik]
	spill	[pɪl]
	spell	[pɛl]
	spot	[pɑt]
	spy	[pāī]

st ---> t

[t]	sting	[tɪŋ]
	step	[tɛp]
	stamp	[tæmp]
	stove	[tōūv]
	stew	[tu]

sk ---> k

[k]	ski	[kiˑ]
	skin	[kɪn]
	scale	[kēīl]
	scoot	[kut]

sl ---> sw ~ səw

[sw]	sleep	[swip] (3)
	slam	[swæm]
	slug	[swʌg]
	sloppy	[swɑpi]
	slip	[swɪp], [səwɪp]
[səw]	sleigh	[səwēɪ]
	sled	[səwɛd]
	slow	[səwōʊ]
	slap	[səwæp]
	slide	[səwāɪd] (2)

sn ---> sw ~ səw

[sw]	sneak	[swik]
	snail	[swēɪl] (2)
	snack	[swæk]
	snow	[swōʊ]
	snake	[swēɪŋk]
[səw]	snap	[səwæp]
	snub	[səwʌn]
	snip	[səwɪp]

sm ---> səw ~ sw

[səw]	smell	[səwɛl]
	smack	[səwæk]
	smock	[səwɑk]
	smile	[səwāɪl]
	smart	[səwāɹt]

[sw]	smog	[swɑg]
	small	[swɑl], [səwɑl]

br ---> br

Follow-up phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> f ~ sf / # ____

[f]	fight	[fɑ͡ɪt]
	food	[fud]
	fake	[fe͡ɪk]
	fall	[fɑl]
	face	[fe͡ɪs]
[sf]	for	[sfɔ͡ɚ]
	fan	[sfæ͡n]
	fun	[sfʌn]
	phone	[sfo͡ʊn]

f ---> f / V ____ V
/ ____ #

v ---> v / # ____
/ V ____ V
/ ____ #

θ ---> θ / # ____
/ V ____ V

θ ---> θ ~ f / ____ #

[θ]	teeth	[tiθ]
[f]	mouth	[mɑ͡ʊf]

ð ---> d ~ ð / # ____

[d]	there	[dɛ̄ð]
	these	[diz]
[ð]	this	[ðɪs], (3), [dɪs] (12)

ð ---> d / V ____ V

[d]	feather	[fɛdð]

s ---> s / # ____ ; V ____ V ; ____ #

z ---> z / # ____ ; V ____ V ; ____ #

ʃ ---> ʃ ~ s / # ____ ; ____ #

[ʃ]	shoe	[ʃu] (3)
	shave	[ʃēɪv]
	shirt	[ʃɜ̄t]
	she	[ʃi]
	show	[ʃōʊ]
	push	[pʊʃ]
	wash	[wɑʃ]
	brush	[brʌʃ]
	crash	[kræʃ]
[s]	shape	[sēɪp]
	shut	[sʌt]

shark [sɑ̄ɹk]

fish [pɪs], [fɪʃ]

ʃ ---> ʃ / V ____ V

ʒ ---> ʒ / V ____ V

h ---> h / # ____

Stops

p ---> p / # ____ ; V ____ V ; ____ #

b ---> b / # ____ ; V ____ V ; ____ #

t ---> t / # ____ ; V ____ V ; ____ #

d ---> d / # ____ ; V ____ V

d ---> d ~ ∅ / ____ #

[d] speed [spid]

food [fud]

sad [sæd]

sled [swɛd]

bread [brɛd]

[∅] side [sāɪ]

bride [brāɪ]

spade [stēɪ]

slide [swāɪ], [swāɪd]

k ---> k / # ____ ; V ____ V ; ____ #

g ---> g / # ____ ; V ____ V ; ____ #

Affricates

ʧ ---> ʧ ~ sʧ / # ____

[ʧ] cheese [ʧiz]

chalk [ʧɔk]

chicken [ʧɪkən]

cheap [ʧip]

chick [ʧɪk]

[sʧ] chair [sʧɛ̄ə], [ʧɛ̄ə]

chin [sʧɪn]

chop [sʧɑp]

chew [sʧu]

chain [sʧēɪn]

ʧ ---> ʧ / V ____ V ; ____ #

ʤ ---> ʤ ~ sʤ / # ____

[ʤ] juice [ʤus]

jail [ʤēɪl]

jeep [ʤip]

		jelly	[ʤɛli]
		gym	[ʤɪm]
	[sʤ]	jack	[sʤæk]
		jump	[sʤʌmp], [ʤʌmp]

ʤ ---> ʤ / V ___ V
___ #

Nasals

m ---> m / # ___
V ___ V
___ #

n ---> n / # ___
V ___ V
___ #

ŋ ---> ŋ / V ___ V
___ #

Liquids

l ---> w / # ___

[w]	laugh	[wæf]
	leaf	[wif] (2)
	leafy	[wifi]
	lip	[wɪp]
	lid	[wɪd]

l ---> l ~ w / V ___ V

[l]	jelly	[ʤɛli]
	vanilla	[nɪlə]
	yellow	[jɛlo͞u]

		television	[tɛləvɪʒən]
		almost	[ɑlmōūst]
	[w]	valentine	[væwəɳtāɪn]
		spatula	[pæʧwə]

l ---> l / ____ #

r ---> r / # ____

/ V ____ V

Glides

w ---> w / # ____

/ V ____ V

j ---> j / # ____

/ V ____ V

Phonetic realizations of consonant clusters

sp ---> sp ~ p

[sp]	speak	[spik]
	spell	[spɛl] (2)
	spy	[spāɪ]
	spot	[spɑt], [pɑt]
	spill	[spɪl] (2), [pɪl]
[p]	spit	[pɪt]
	speck	[pɛk]
	spoon	[pun]
	spider	[pāɪdɚ]
	spatula	[pæʧwə]

st ---> st ~ t

[st]	sting	[stɪŋ]
	stop	[stɑp] (3)
	stew	[stu]
	stem	[stɛm]
	stone	[stoʊ̄n]
[t]	step	[tɛp]
	stairs	[tɛ̄ɚ̄z] (2)
	stove	[toʊ̄v]
	star	[tɑ̄ɚ̄] (3)
	stuff	[tʌf]

sk ---> sk ~ k

[sk]	skip	[skɪp]
	skirt	[skɝ̄t]
	skinny	[skɪni]
	skill	[skɪl]
	scale	[skē͡ɪl]
[k]	skin	[kɪn]
	skating	[kē͡ɪnɪŋ]
	scarf	[kɑ̄ɚ̄f]
	ski	[ki] (2)
	school	[kul] (3), [skul] (2)

sl ---> sw

[sw]	slow	[swoʊ̄]
	slap	[swæp]
	slug	[swʌg]

	sled	[swɛd]
	sleigh	[swēɪ]

sn ---> sw

[sw]	sneak	[swɪŋk]
	snip	[swɪmp]
	snake	[swēɪŋk] (3)
	snap	[swæp]

sm ---> sw ~ sm

[sw]	smell	[swɛl] (2)
	smack	[swæk] (2)
	smoke	[swōʊk]
	small	[swɑl] (2)
	smile	[swāɪl] (2)
[sm]	smock	[smɑk]
	smug	[smʌg]

br ---> br ~ sbr

[br]	brick	[brɪk]
	bridge	[brɪʤ]
	bread	[brɛd]
	brew	[bru]
	brush	[brʌʃ]
[sbr]	brim	[sbrɪm]
	break	[sbrēɪk], [brēɪk]
	brain	[sbrēɪn]
	bran	[sbræn]

APPENDIX I
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 4

APPENDIX I: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 4.

Subject 4

Pretraining phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> p~b / # ____

[p]	fishing	[pɪsɪŋ]
	face	[pēɪs]
	fat	[pæt], [bæt]
	for	[pɔ] (2), [bɔ̄ə̄]
[b]	fight	[bāɪt]
	feed	[bid]
	five	[bāɪb]
	fork	[bʌk]
	fan	[bæn]

f ---> p / V ____ V
/ ____ #

[p]	coughing	[kɑpɪŋ]
	knife-i	[nāɪpi]
	laughing	[læpɪŋ]
	leafy	[lipi]
	roof-i	[wupi]
	scarf	[kɑp]
	knife	[nāɪp]
	laugh	[læp]

		leaf	[lip], [lis]
		roof	[wup]
v ---> b	/	# ____	
	/	V ____ V	
	[b]	vacuum	[bækʊm]
		vanilla	[bɛlə]
		vat	[bæt]
		vine	[bāɪn]
		vase	[bēɪs] (2)
		shaving	[tēɪbɪŋ]
		driving	[dāɪbɪŋ]
		waving	[wēɪbɪŋ]
		glove-i	[gɪbi]
		stove-i	[tōʊbi]
v ---> b	/	____ #	
	[b]	shave	[ʃēɪb]
		five	[bāɪb]
		wave	[wēɪb]
		glove	[gɪə̄b], [gʌb]
		stove	[tōʊb]
θ ---> b ~ t	/	# ____	
	[b]	thumb	[bʌm]
	[t]	thought	[tɔ]
θ ---> f ~ p	/	____ #	
	[f]	mouth	[māʊf]
	[p]	tooth	[tup]

ð ---> d / # ___

[d]	the	[dɪ]
	this	[dɪʔ], [tɪ]
	that	[dæ] (3)
	them	[dɪ] (2)
	there	[dɛ̄ə]

ð ---> ð / V ___ V

s ---> j ~ s ~ sj / # ___

[j]	sock	[jɑk]
	sun	[jɪ̄ən]
	sad	[jæd]
	sell	[jɪl]
	sack	[jæk]
[s]	sir	[sʊ]
	sent	[sɪ̄əp]
[sj]	soup	[sjup]
	sick	[sjɪk]

s ---> s / V ___ V

s ---> s ~ ʔ / ___ #

[s]	bus	[bɪs]
	juice	[dus]
	mouse	[mɑ̄ʊ̄s]
	dress	[dɪs]
	ice	[ɑ̄ɪs]
[ʔ]	house	[hɑ̄ʊ̄ʔ]

		this	[dɪʔ], [tɪʔ]
		yes	[jɛʔ]
z ---> j ~ z		/ # ___	
	[j]	zoo	[jul], [ju]
		Ziggy	[jɪgi]
		zap	[jæp]
		zinc	[jik]
		zero	[jɛwo]
	[z]	zebra	[zibə], [dɪbə]
		zing	[zɪŋg]
		zone	[zo͞un]
		zany	[ze͞ini]
z ---> z ~ j		/ V ___ V	
	[z]	cheesy	[tizi]
		noisy	[nɔ͞izi]
		music box	[juzɪbɑʔ]
	[j]	rosy	[wo͞uji]
z ---> z ~ ∅ ~ ʃ		/ ___ #	
	[z]	cheese	[tiz]
		noise	[nɔ͞iz]
		stairs	[ti͞əz] (2)
		buzz	[bʌz]
		nose	[no͞uz]
	[∅]	was	[wɪ]
		bears	[bɔ], [bi͞əz]
		because	[bɪki]

	[ʃ]	Claus	[kwɔʃ]
		rose	[wo͞uʃ]
ʃ ---> j ~ ʃ		/ # ___	
	[j]	shirt	[jʊt]
		shake	[je͞ik]
		sheep	[jip]
		show	[jo͞u]
		shoe	[ju] (2), [ʃu]
	[ʃ]	shave	[ʃe͞ib]
		shampoo	[ʃæpu]
ʃ ---> ʃ ~ s		/ V ___ V	
	[ʃ]	pushing	[pʊʃɪŋ]
		washing	[wæʃɪŋ]
	[s]	brushing	[bɛsɪŋ]
		fishing	[pɪsɪŋ]
ʃ ---> s ~ ʃ		/ ___ #	
	[s]	fish	[pɪs], [bɪ͞əs]
		brush	[bɪs]
		crash	[kæs]
		toothbrush	[tubɪs]
	[ʃ]	wash	[waʃ]
		push	[bʊʃ], [pʊ]
ʒ ---> ʤ		/ V ___ V	
	[ʤ]	television	[tɛləbɪʤən]
h ---> h		/ # ___	

Stops

p ---> p ~ b / # ____
/ V ____ V

[p]	peach	[piʃ]
	pie	[pa͡ɪ]
	pull	[pul]
	paint	[pe͡ɪnt]
	pot	[pɑt]
	soupy	[jupi]
	chip-i	[tɪpi]
	Snoopy	[nupi]
	soapy	[jo͡upi]
	sloppy	[lɑpi]
[b]	punch	[bɪʔs]
	pig	[bɪg]
	push	[buʃ], [pʊ]
	put	[bʊ], [pʊʔ]
	cup-i	[kʌbi]

p ---> p / ____ #
/ # ____
b ---> b / V ____ V
/ ____ #
t ---> t / # ____
t ---> t ~ d / V ____ V

[t]	eating	[itɪŋ]
	bootie	[buti]

		cutting	[kɪtɪŋ]
		skating	[kēɪtɪŋ]
		valentine	[bæləntāɪm]
	[d]	biting	[bāɪdɪŋ]
		sweater	[wɛdu]
		skeleton	[kæləd ɪn]
t ---> t ~ ∅		____ #	
	[t]	fight	[bāɪt]
		eat	[it]
		shirt	[jʊt]
		kite	[kāɪt]
		start	[tɑt]
	[∅]	that	[dæ]
		thought	[tɔ]
		out	[ɔ̄ə̄]
		# ____	
d ---> d		V ____ V	
		____ #	
		# ____	
k ---> k		V ____ V	
		____ #	
		# ____	
g ---> g		V ____ V	
		____ #	

Affricates

ʧ ---> t # ____

	[t]	cheese	[tiz]
		chin	[tɪ̄ə̄n]
		chop	[tap]
		chew	[tu]
		chain	[tē ɪn]
ʧ ---> ʔj ~ j		V ____ V	
	[ʔj]	catching	[kɪʔjɪŋ]
		peachy	[piʔji]
	[j]	watch-i	[waji]
ʧ ---> ʔʃ ~ ʃ		____ #	
	[ʔʃ~ʃ]	catch	[kɪʔʃ]
		peach	[piʃ]
		watch	[waʔʃ], [waʃ]
ʤ ---> d		# ____	
	[d]	juice	[dus]
		jeep	[dip]
		gym	[dɪm]
		jar	[dɑ̄ə̄]
		job	[dap]
ʤ ---> z		V ____ V	
	[z]	page-i	[pē ɪzi]
		badge-i	[bæzi]
		bridge-i	[bɪzi]
		cage-i	[kē ɪzi]
ʤ ---> s ~ ʧ ~ ʃ		____ #	
	[s]	bridge	[bɪs]

	cage	[kēɪs]
[ʧ]	page	[pēɪs], [pēɪʧ]
[ʃ]	badge	[bæ?ʃ]

Nasals

m ---> m / # ____

m ---> m ~ n ~ ø / ____ #

[m]	vacuum	[bækʊm]
	gym	[dɪm]
	gum	[gʌm]
	thumb	[bɪm]
	same	[jēɪm]
[n]	comb	[kōūn]
	zoom	[djun]
	stem	[tɪn]
[ø]	them	[dɪ] (2)
	him	[hɪ] (2), [hɪm]

n ---> n / # ____ ; V ____ V ; ____ #

ŋ ---> k / V ____ V

[k]	hanger	[hēɪkʊ]

ŋ ---> ŋ / ____ #

Liquids

l ---> l / # ____ ; V ____ V ; ____ #

r ---> w / # ____
V ____ V

[w]	roof	[wup]
	rose	[wo͞uʃ]
	ride	[wɑ͞id]
	wrong	[wɔn]
	rosy	[wo͞uji]
	zero	[jɪwo]

Glides

w ---> w / # ____
V ____ V

j ---> j / # ____
V ____ V

Phonetic realizations for consonant clusters

sp ---> p ~ b

[p]	speak	[pɪk]
	spell	[pɛl] (2)
	spool	[pul]
	spy	[pɑ͞i]
	spider	[pɑ͞idʊ]
[b]	speed	[bid]
	spoil	[bɔ͞i]
	spike	[bɑ͞ik]
	spot	[bɑt], [pɑt]

st ---> t

[t]	stem	[tɪn]

	stew	[tu]
	stone	[tōʊ̄n]
	stop	[tɑp] (3)
	stand	[tɛnd]

sk ---> k

[k]	skin	[kɪn]
	skate	[kēɪ̄t] (2)
	scat	[kæt]
	scoot	[kut]
	scarf	[kɑp]

sl ---> l ~ sl

[l]	sleep	[lip] (3)
	slip	[lɪp] (2)
	sleigh	[lēɪ̄]
	sloppy	[lɑpi]
	slow	[lōʊ̄] (2)
[sl]	sled	[slɪ̄ə̄t]

sn ---> n

[n]	sneak	[nik]
	snakes	[nēɪ̄ks]
	snow	[nōʊ̄]
	snap	[næp]
	snip	[nɪp]

sm ---> m

[m]	smell	[mɛl]
	smack	[mæk]

	small	[mal] (2)
	smoke	[mo͞uk] (2)
	smile	[ma͞iz̩], [ma͞ij̩]

br ---> b

[b]	brick	[bɪ͞ək]
	brain	[be͞ɪn]
	brew	[bu]
	broke	[bo͞uk]
	brush	[bɪs]

Follow-up phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> b ~ p / # ____

[b]	fight	[ba͞ɪt]
	feed	[bid]
	face	[be͞ɪs]
	five	[ba͞ɪb]
	fork	[bʌk]
[p]	for	[pɔ͞ə]
	fire	[pa͞ɪju]

f ---> p / V ____ V
/ ____ #

[p]	coughing	[kɔpɪn]
	knife-i	[na͞ɪpi]
	laughing	[læpɪn]
	leafy	[lipi]

		cough	[kɑ̄p]
		knife	[nāɪp]
		leaf	[lɪ̄p], [lis]
		laugh	[lǣp]
		roof	[wup]
v ---> b	/ # ____ V ____ V ____ #		
	[b]	vine	[bāɪn]
		vacuum	[bǣwʊm]
		vanilla	[bənɪlə]
		vet	[bɛt]
		vote	[bōʊ̄t]
		shaving	[ʃēɪ bɪŋ]
		driving	[dɑ̄ɪ bɪn]
		waving	[wēɪ bɪŋ]
		shovel	[jʌbl̩]
		stove-i	[tōʊ̄bi]
		shave	[ʃēɪ b]
		drive	[dɑ̄ɪb]
		wave	[wēɪ b]
		five	[bāɪ b]
		stove	[tōʊ̄b] (2)
θ ---> b ~ t	/ # ____		
	[b]	thumb	[bɛ̄əm]
	[t]	thanks	[tēɪʔs]

θ ---> f / V ___ V

[f]	nothing	[nʌfɪn]

θ ---> s ~ p / ___ #

[s]	teeth	[tis]
[p]	mouth	[maʊp]

ð ---> d / # ___
/ V ___ V

[d]	the	[də] (3), [dɪ]
	that	[dæt] (2)
	these	[diz] (2)
	this	[dɪs] (8), [dɪʔ]
	feather	[bɛdʊ]

s ---> j ~ s ~ sj / # ___

[j]	sock	[jɑk]
	soup	[jup]
	sad	[jæd]
	sell	[jɛl]
	sick	[jɪk]
[s]	same	[seɪm]
	sent	[sɪət]
	santa	[sɛntə], [jɛntə]
	see	[si], [ji]
	soap	[soʊp], [joʊp], [sjoʊp]
[sj]	soupy	[sjupi]
	sock-i	[sjɑki]

s ---> s / V ____ V
/ ____ #

z ---> j ~ z / # ____
/ V ____ V

[j]	zap	[jæp]
	zing	[jɪŋ]
	zone	[jo͞un]
	zany	[je͞ɪni]
	zero	[jɪwo]
	rosy	[wo͞uji]
	nosy	[no͞uji]
[z]	zebra	[zɪbə], [jɪbə]
	zoo	[zu], [ju]
	zipping	[zɪpɪŋ]
	zoom	[zum]
	zip	[zɪp]
	buzzing	[bʌzɪŋ]
	cheesy	[tʃizi]
	noisy	[nɔ͞ɪzi]

z ---> z / ____ #

ʃ ---> ʃ ~ j ~ d / # ____

[ʃ]	she	[ʃi]
	shape	[ʃe͞ɪp]
	ship	[ʃɪp]
	shave	[ʃe͞ɪb]
	shirt	[ʃɝt]

	[j]	shoe	[ju], [ʃu] (2)
		shake	[jēɪk]
		show	[jōʊ]
		shampoo	[jɛmpu]
		shovel	[jʌbl̩]
	[ʤ]	shut	[ʤʌt]
		shark	[ʤɑk]
ʃ ---> ʃ	/	V ___ V	
ʃ ---> ʃ ~ s	/	___ #	
	[ʃ]	wash	[wɑʃ]
		brush	[bɹʃ]
		crash	[kæʃ]
		fish	[bɹʃ], [bɹs]
		toothbrush	[tubɹʃ]
	[s]	push	[pʊs]
		fish	[bɹʃ], [bɹs]
ʒ ---> ʒ	/	V ___ V	
h ---> h	/	# ___	
	/	V ___ V	

<u>Stops</u>

p ---> p ~ b	/	# ___	
	[p]	push	[pʊs]
		pie	[pāɪ]
		pig	[pɹg]
		pill	[pɹl]
		put	[pʊ]

[b] peas [bi]

pot [bɑt] (2), [pɑt]

page [bēɪʒ], [pēɪʃ]

peach [biʧ]

pudding [bʊdɪ], [pʊdɪ]

p ---> p / V ____ V
____ #

b ---> b / # ____
V ____ V
____ #

t ---> t / # ____
V ____ V
____ #

d ---> d / # ____
V ____ V
____ #

k ---> k / # ____
V ____ V
____ #

g ---> g / # ____
V ____ V
____ #

Affricates

ʧ ---> t ~ d / # ____

[t] cheese [tiz]

chip [tɪp] (2)

	chicken	[tɪkən]
	cheap	[tip]
	chew	[tu]
[d]	chat	[dæt], [tæt]
	chop	[dɑp]
	chain	[dēɪn]

ʧ ---> ʔj ~ ʧ ~ ʔʃ ~ t / V ___ V

[ʔj]	catching	[kɛʔjɪŋ]
	watch-i	[wɑʔjɪ]
[ʧ]	peachy	[pɪʧɪ]
[ʔʃ]	"pinchin"	[pɪʔʃɪn]
[t]	punching	[pɪtɪŋ]

ʧ ---> ʔʃ ~ ʧ ~ t / ___ #

[ʔʃ]	watch	[wɑʔʃ] (2)
[ʧ]	peach	[biʧ]
[t]	catch	[kɪt]

ʤ ---> d ~ t / # ___

[d]	gym	[dɪ̄əm]
	jack	[dæk]
	jar	[dɑ]
	Jill	[dɪl]
	jump	[dɪp]
[t]	juice	[tus]
	gee	[tɪ]
	joke	[tōūk]

ʤ ---> ʒ ~ ʤ / V ___ V

[ʒ]	page-i	[pēɪʒi]
	bridge-i	[bɪʒi]
	cage-i	[kēɪʒi]
[ʤ]	badge-i	[bæʤi]

ʤ ---> ʃ ~ ʤ / ___ #

[ʃ]	page	[pēɪʃ], [pēɪʒ]
	bridge	[bɪʃ]
	badge	[bæʃ]
[ʤ]	cage	[kēɪʤ]

Nasals

m ---> m / # ___ ___ #

n ---> n / # ___ V ___ V ___ #

ŋ ---> ŋ / V ___ V

ŋ ---> ŋ ~ ø / ___ #

[ŋ]	buzzing	[bʌzɪŋ]
	swing	[wɪŋ]
	brushing	[bɪʃɪŋ]
	cutting	[kɪtɪŋ]
	fishing	[bɪʃɪŋ]
[ø]	pushing	[pʊsi]
	pudding	[pʊdɪ], [bʊdɪ]

Liquids

l ---> l / # ____ ; V ____ V ; ____ #

r ---> w / # ____ ; V ____ V

[w]	roof	[wup]
	rose	[wōūz]
	rocky	[wɑkɪ]
	room	[wum]
	rock	[wɑk] (2)
	zero	[jɪwo]

Glides

w ---> w / # ____ ; V ____ V

j ---> j / # ____ ; V ____ V

Phonetic realizations for consonant clusters

sp ---> p ~ sp

[p]	spill	[pɪl] (3)
	spoon	[pun] (2)
	spider	[pāɪdʊ]
	spend	[pɛnd]
	speak	[pik] (2)
[sp]	spit	[spɪt]

st ---> t ~ st

[t]	stem	[tɛm]
	step	[tɪp]
	star	[tɑ] (2)
	stuff	[tɪp]
	start	[tɑt]
[st]	stone	[stōōn]
	stake	[stēɪk]
	stab	[stæb]
	stand	[stænd]
	state	[stēɪt]

sk ---> k ~ sk

[k]	skinny	[kɪni]
	skill	[kɪl]
	Scott	[kɑt]
	skunk	[kʌk]
	skip	[kɪp]
[sk]	ski	[ski], [ki]

sl ---> l

[l]	slow	[lōō]
	slap	[læp]
	slam	[læm]
	sled	[lɛd]
	sleigh	[lēɪ]

sn ---> n

[n]	snip	[nɪp]
	snap	[næp]

	snow	[nō͡ʊ]
	Snoopy	[nupi]
	sneak	[nik]

sm ---> m

[m]	smoke	[mō͡ʊk]
	smart	[mɑt]
	smug	[mʌg]
	smack	[mæk]
	smell	[mɛl] (2)

br ---> b

[b]	brick	[bɪk]
	bread	[bɛ̄ə̄d]
	brown	[bɑ̄ʊ̄n]
	bright	[bɑ̄ɪ̄t]
	brush	[bɪʃ]

APPENDIX J
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 5

APPENDIX J: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 5

Subject 5

Pretraining phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> b ~ p ~ f / # ___

[b]	fight	[bāɪt]
	feed	[bid]
	fat	[bæt] (2)
	five	[bāɪv]
	fun	[bʌn]
[p]	fish	[pɪd], [bɪd]
	face	[pēɪt]
	fork	[pɔ̄ə̄t], [fɑt]
	feather	[pɛdu]
	fan	[pæn]
[f]	fake	[fēɪk]
	food	[fud]
	first	[fʊm]

f ---> p / V ___ V

[p]	coughing	[kɑpɪŋ]
	laughing	[wæpɪŋ]
	leafy	[wipi]
	roof-i	[wupi]
	transformer	[tænpɔmʊd]

f ---> p ~ f / ____ #

[p]	knife	[nɑ̄ɪp]
	roof	[wup]
	leaf	[wi̇p] (2)
[f]	laugh	[wæf]
	scarf	[kɑf]
	cough	[kɔf]

v ---> b / # ____

[b]	vat	[bæt]
	verb	[bud]
	vet	[bɛt]
	Vic	[bɪt]
	vote	[bo͞ʊt]

v ---> b / V ____ V

[b]	shaving	[tē͡ɪbɪŋ]
	driving	[drɑ̄͡ɪbɪŋ]
	waving	[wē͡ɪbɪŋ]
	shovel	[dʌbl̩]
	television	[tɛləbɪdən]

v ---> v ~ b / ____ #

[v]	shave	[tē͡ɪv]
	glove	[gwʌv] (2)
	five	[bɑ̄͡ɪv]
	wave	[wē͡ɪv]
	of	[ʌv] (2)
[b]	drive	[dwɑ̄͡ɪb]

		stove	[tōʊ̄b]
θ ---> t	/ # ____		
	[t]	thumb	[tʌm]
θ ---> p	/ ____ #		
	[p]	teeth	[tiːp]
		mouth	[māʊ̄p]
ð ---> d	/ # ____		
	/ V ____ V		
	[d]	the	[də] (5)
		they	[dēɪ̄] (3)
		that	[dæ] (3), [dɛn], [dæt]
		this	[dɪs], [dɪ] (3), [dɪd], [dɪʔ]
		together	[tugɛdʊ]
		another	[nʌdə]
s ---> t ~ d	/ # ____		
	[t]	sock	[tɑt]
		soup	[tup]
		sun	[tʌn]
		soupy	[tupi]
		Santa	[tænə] (2)
	[d]	sell	[dɛl]
		say	[dēɪ̄]
		seat	[dit]
		same	[dēɪ̄m]
		sick	[dɪt]

s ---> t	/	V ____ V	
		____ #	
[t]		icy	[ɑ̄ɪti]
		icing	[ɑ̄ɪtɪ]
		dressy	[dwɛtɪ]
		mousy	[mɑ̄ʊ̄tɪ]
		bus-i	[bʌti]
		juice	[dut]
		ice	[ɑ̄ɪt]
		dress	[dwɛt]
		mouse	[mɑ̄ʊ̄t]
		face	[pēɪt]
z ---> d	/	# ____	
		V ____ V	
[d]		zipping	[dɪpɪŋ]
		Ziggy	[dɪdɪ]
		zap	[dəwæp]
		zone	[dōʊ̄n]
		zip	[dɪp]
		noisy	[nɔ̄ɪdɪ]
		rosy	[wōʊ̄dɪ]
		nosy	[nōʊ̄dɪ]
		buzzing	[bʌdɪn]
		music box	[mudɪkbɑt]

Examples are provided for four realizations that occurred only once in the initial position:

	[z]	zing	[zɪŋg]
	[t]	zoo	[tu], [du]
	[d]	zebra	[ʤi bə], [dibwə]
	[dw]	zipper	[dwɪpʊ], [dɪpʊ]
z ---> d ~ ∅		/ ___ #	
	[d]	buzz	[bʌd]
		cheese	[tid]
		rose	[wōūd]
		nose	[nōūd] (2)
		glasses	[gwæʤɪd]
	[∅]	noise	[nɔ̄ɪ]
		stairs	[tɛ̄ū]
		Claus	[kwɔ]
ʃ ---> d		/ # ___	
	[d]	she	[di]
		shovel	[dʌbl̩]
		shake	[dēik]
		sheep	[dip]
		shut	[dʌt]
ʃ ---> d ~ t		/ V ___ V	
		___ #	
	[d]	brushing	[bwʌdɪŋ]
		washing	[wadɪŋ]
		push	[pʊd]
		toothbrush	[tubwʌd]
		fish	[bɪd], [pɪd]

	[t]	fishing	[pɪtɪŋ]
		pushing	[bʊtɪŋ]
		crashing	[kwætɪŋ]
		wash	[wɑt]
		brush	[bwʌt]
		crash	[kwæt]
ʒ ---> d	/ V ____ V		
	[d]	television	[tɛləbɪdən]
h ---> ∅ ~ h	/ # ____		
	[∅]	hat	[æt]
		hanger	[ɛnōʊ]
	[h]	here	[hɪ̄ɚ]

Stops

p ---> p	/ # ____		
	/ V ____ V		
	/ ____ #		
b ---> b	/ # ____		
	/ V ____ V		
	/ ____ #		
t ---> t	/ # ____		
	/ V ____ V		
	/ ____ #		
d ---> ɗ	/ # ____		
	/ V ____ V		
d ---> d ~ ∅	/ ____ #		
	[d]	feed	[bid]

		food	[fud]
		bread	[bwɛd]
		koolade	[kulēɪd]
		sled	[təwɛd]
	[∅]	bride	[bwāɪ]
		did	[dɪ]
		sad	[dæ]
k ---> k ~ g		/ # ___	
	[k]	cake	[kēɪk]
		cage	[kēɪd]
		cough	[kɔf]
		key	[ki]
		cool	[kul]
	[g]	comb	[gōūm]
		cup	[gʌp]
		cup-i	[gʌpi]
k ---> t		/ V ___ V	
	[t]	back-i	[bæti]
		bookie	[bʊti]
		rocky	[wɑti]
		sock-i	[tɑti]
		sneaky	[niti]
k ---> t ~ k		/ ___ #	
	[t]	back	[bæt]
		book	[bʌt]
		duck	[dʌt]

	sock	[tɑt]
	sick	[dɪt]
[k]	cake	[kēɪk]
	fake	[fēɪk]
	shake	[dēɪk]
	broke	[bwōʊk]
	spoke	[pōʊk]

g ---> g / # ____
V ____ V

g ---> g ~ d / ____ #

[g]	pig	[bɪg]
	smug	[mʌg]
	smog	[mɑg]
[d]	egg	[ēɪd]
	big	[bɪd] (2)

Affricates

ʧ ---> d ~ t / # ____

[d]	chin	[dɪn]
	chop	[dɑp]
	chain	[dēɪn]
	cheap	[dip]
	chick	[dɪt]
[t]	cheese	[tid]
	chalk	[tɑt]
	chicken	[tɪʔən]
	cheesy	[titi]

	chip-i	[tɪpi]
ʧ ---> t ~ k	/ V ___ V	
	___ #	
[t]	catching	[kɛtɪn]
	watch-i	[watɪ]
	catch	[kɛt]
	watch	[wat] (2)
[k]	peachy	[pikɪ]
	peach	[pik]
ʤ ---> d ~ t	/ # ___	
[d]	juice	[dut]
	jeep	[dip]
	Jill	[dɪl]
	joke	[dōūt]
	job	[dab]
[t]	joy	[tɔ̄ɪ]
	jar	[tan]
	jump	[tʌmt], [dʌmp]
ʤ ---> d ~ ʤ	/ V ___ V	
[d]	page-i	[pēɪdi]
	badge-i	[bædi]
	cage-i	[kēɪdi]
[ʤ]	bridge-i	[bwɪʤi]
ʤ ---> d	/ ___ #	
[d]	page	[pēɪd] (2)
	bridge	[bwɪd]

	badge	[bæd]
	cage	[kēɪd]

Nasals

m ---> m / # ____ ; V ____ V ; ____ #

n ---> n / # ____ ; V ____ V ; ____ #

ŋ ---> n / V ____ V

[n]	hanger	[ɛnōʊ]

ŋ ---> ŋ ~ n ~ ∅ / ____ #

[ŋ]	brushing	[bwʌdɪŋ]
	coughing	[kɔpɪŋ]
	wing	[wɪŋ]
	fishing	[pɪtɪŋ]
	pushing	[bʊtɪŋ]
[n]	buzzing	[bʌdɪn]
	catching	[kɛtɪn]
	eating	[iʔən]
	pinching	[pɪntɪn]
[∅]	skating	[kēɪtɪ]
	icing	[āɪtɪ]

Liquids

l ---> w / # ____

[w]	laugh	[wæf]

		lip	[wɪp]
		like	[wɑ̄ɪk]
		lots	[wɑt]
		leaf	[wɨp] (2)

l ---> l ~ w / V ___ V

[l]	jelly	[dɛlɨ]
	vanilla	[nɪlə]
	television	[tɛləbɪdən]
	skeleton	[kɛlədən]
	koolade	[kʊlē͡ɪd]
[w]	skillet	[kɪwɪt] (2)

l ---> l ~ ∅ ~ V / ___ #

[l]	nail	[nē͡ɪl]
	cool	[kul]
	pill	[pɪl]
	sell	[dɛl]
	pull	[pul]
[∅]	all	[ɑ] (2)
	fall	[bɔ]
	school	[dʊ], [kul] (3)
	small	[mɑ], [mɑl]
[V]	tail	[tɛ̄ō]
	crystal	[tɪtʊ]
	candle	[kǣnō͡ʊ]

r ---> w / # ___
V ___ V

[w]	roof	[wup]
	rose	[wo͞ʊd]
	rocky	[wɑti]
	rosy	[wo͞ʊdi]
	robot	[wo͞ʊbɑt]
	zero	[diwo]
	orange	[owɪnd]
	orange-i	[owɪndʒi]

Glides

w ---> w / # ____
V ____ V

j ---> j / # ____
V ____ V

Phonetic realizations for consonant clusters

sp ---> p

[p]	spin	[pɪn] (4)
	spend	[pɛn]
	spy	[pɑ͞ɪ]
	spider	[pɑ͞ɪdʊ]
	spoke	[po͞ʊk]

st ---> t

[t]	sting	[tɪŋ]
	step	[tɛp]
	stand	[tæn]
	stone	[to͞ʊn]
	start	[tɑt]

sk ---> k

[k]	skinny	[kɪniˑ]
	skill	[kɪl]
	skip	[kɪp]
	skeleton	[kɛləd̬ən]
	scoot	[kup]

sl ---> dw ~ tw

[dw]	slow	[dwo͞ʊ]
	sly	[dwa͞ɪd]
	sleigh	[dwe͞ɪ]
	slug	[dwʌd]
	slide	[dwa͞ɪd], [twa͞ɪd]
[tw]	sleeping	[twˈipɪŋ]
	sloppy	[twɑpiˑ]
	slip	[twɪp], [dɪp]
	sleep	[twˈip] (2), [dwˈip]

There was also one occurrence of each of the following:

[d]	slam	[dəwæm]
[t]	sled	[təwɛd]
[l]	slap	[læp]

sn ---> n

[n]	snip	[nɪp]
	snakes	[ne͞ɪt]
	snap	[næp]
	Snoopy	[nupiˑ]
	snow	[no͞ʊ]

sm ---> m

[m]	smell	[mɛl] (2)
	smack	[mæt]
	smart	[mɑt]
	smug	[mʌg]
	smoke	[mo͞ʊt], [mo͞ʊk]

br ---> bw

[bw]	brick	[bwɪt]
	brown	[bwɑ͞ʊn]
	bright	[bwɑ͞ɪt]
	brush	[bwʌt]
	bread	[bwɛd]

Follow-up phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> f∼p / # ____

[f]	fight	[fɑ͞ɪt]
	feed	[fɪn]
	five	[fɑ͞ɪv]
	food	[fu]
	fun	[fʌn]
[p]	face	[pe͞ɪ]
	fire	[pɑ͞ɪʊ]
	fork	[pʊt]
	feather	[pɛdʊ]

f ---> f∼p∼v / V ____ V

	[f]	laughing	[wæfɪŋ]
		leafy	[wifi]
		roof-i	[wufi]
	[p]	coughing	[kɔpɪŋ]
	[v]	knife-i	[nāɪvi]
f ---> f ~ p		/ ___ #	
	[f]	laugh	[wæf]
		leaf	[wif] (2)
		roof	[wuf]
		knife	[nāɪf]
		scarf	[kaf]
	[p]	cough	[kɔp]
		/ # ___	
v ---> v		V ___ V	
		___ # /	
θ ---> t		/ # ___	
	[t]	thumb	[tʌm]
θ ---> f		/ V ___ V	
	[f]	"nothin"	[nʌfɪn]
θ ---> f ~ t		/ ___ #	
	[f]	teeth	[tif]
		mouth	[māʊf]
	[t]	with	[wɪt]
ð ---> d		/ # ___	
		V ___ V /	
	[d]	they	[dēɪ]

	that	[dæt] (3)
	them	[dɪn]
	then	[dɛn]
	the	[də] (4), [dʌ]
	other	[ʌdə]
	another	[ənʌdə] (2)
	feather	[pɛdʊ]

s ---> d ~ t / # ____

[d]	sock	[dɑt]
	sad	[dæd]
	sick	[dɪt]
	saw	[dɔ]
	soapy	[dō͡ʊpi]
[t]	soup	[tup]
	Santa	[tænə] (2)
	sun	[tʌn]
	sell	[tɛl]
	seat	[tit]

There were also one occurrence for each of the following:

[s]	some	[sʌm]
[st]	soap	[stō͡ʊp], [tō͡ʊp]

s ---> t / V ____ V

[t]	bus-i	[bʌti]
	juicy	[tuti]
	mousy	[mā͡ʊti]

	icy	[aɪti]

s ---> t ~ ∅ / ___ #

[t]	juice	[ʤut]
	mouse	[maʊt]
	horse	[hʊt]
	ice	[aɪt], [aɪ] (2)
	this	[dɪt] (3), [dɪ] (2), [dɪs]
[∅]	vase	[veɪ], [veɪd]
	face	[peɪ]

z ---> d ~ z / # ___

[d]	Ziggy	[dɪdi]
	zing	[dɪŋ]
	zone	[doʊn]
	zip	[dɪp]
	zero	[diwo]
[z]	zany	[zeɪni]
	zoo	[zu], [du]

The phoneme /d/ had the most occurrences making up 10 of the total 16 examples. There was only one occurrence of /t/, /ʤ /, and /sd/.

z ---> d / V ___ V

[d]	cheesy	[tidi]
	noisy	[nɔɪdi]
	rosy	[woʊdi]
	nosy	[noʊdi]
	buzzing	[bʌdɪŋ]

z ---> ø ~ d / ____ #

[ø]	cheese	[tiˑ]
	noise	[nɔ̄ɪ]
	toes	[tōʊ̄]
	does	[dʌ]
	goes	[gōʊ̄]
[d]	buzz	[bʌd]
	rose	[wōʊ̄d]
	glasses	[gwǣdɪd]

ʃ ---> t ~ d ~ st / # ____

[t]	shave	[tēɪ̄v]
	shampoo	[tæmfu]
	shape	[tēɪ̄p]
	ship	[tɪp]
	shoe	[tu] (3)
[d]	shirt	[dʊt]
	shovel	[dʌvl̩]
	she	[diˑ]
	shake	[dēɪ̄t]
	shut	[dʌt]
[st]	shark	[stɑt]
	sheep	[stiˑp]

The two examples of /ʃ/ ---> /st/ should be considered overgeneralization of the /s/ + stop cluster.

ʃ ---> d ~ ʧ ~ ʤ / V ____ V

[d]	brushing	[fwʌdɪŋ]

		pushing	[pʊdɪŋ]
	[ʧ]	washing	[waʧɪŋ]
		crashing	[kwæʧɪŋ]
	[ʤ]	fishing	[fɪʤɪŋ]

ʃ ---> d ~ ʃ / ____ #

	[d]	brush	[fwʌd]
		crash	[kwæd]
		toothbrush	[tufwʌd]
	[ʃ]	wash	[waʃ]

ʒ ---> d / V ____ V

	[d]	television	[tɛləvɪdɪn]

h ---> h ~ ∅ / # ____

	[h]	hey	[hēɪ]
		hot	[hɑt]
		here	[hɪ͡ʊ]
	[∅]	hat	[æt]
		hanger	[æ͡ŋʊ]

<u>Stops</u>

p ---> p ~ f / # ____
V ____ V

	[p]	pie	[pā͡ɪ]
		pig	[pɪd]
		pill	[pɪl]
		put	[pʊt]
		peach	[pit]
		soupy	[tupi]

	chip-i	[tɪpi]
	cup-i	[kʌpi]
	Snoopy	[dupi]
	soapy	[dō͞ūpi]
[f]	push	[fʊn]
	pin	[fɪn]
	pull	[fʊl]
	page	[fē͞ɪd], [pē͞ɪ]
	sloppy	[twɑfi]

p ---> p ~ f / ___ #

[p]	soup	[tup]
	cup	[kʌp]
	lip	[wɪp]
	top	[tɑp]
	chop	[dɑp]
[f]	zap	[næf]

b ---> b / # ___
V ___ V

b ---> b ~ v ~ m ~ n ~ ∅ ~ d / ___ #

[b]	tub	[tʌb]
	jab	[dæb]
[v]	snub	[nʌv]
	stab	[sæv]
[m]	job	[dɑm]
[n]	cob	[kɑn]
[d]	verb	[vʊd]

	[Ø]	bribe	[fwāɪ]
t ---> t	/ # ___		
t ---> t ~ d	/ V ___ V		
	[t]	eating	[iṭɪŋ]
		bootie	[buṭi]
		cutting	[kʌṭɪŋ]
		fatty	[fæṭi]
		biting	[bāɪṭɪŋ]
	[d]	sweater	[twɛdə]
		skeleton	[kɛlədɪn]
t ---> t	/ ___ #		
	[t]	eat	[iṭ]
		boot	[buṭ]
		cut	[kʌṭ]
		bite	[bāɪṭ]
		coat	[kōūṭ]
d ---> d	/ # ___		
	/ V ___ V		
d ---> d ~ n ~ Ø	/ ___ #		
	[d]	speed	[fid]
		sad	[dæd]
		braid	[fwēɪd]
		spade	[fēɪd]
		brad	[fwæd]
	[n]	sled	[twɛn]
		feed	[fin]

		bread	[fwɛ̄ən]
		bride	[fwɑ̄ɪn]
	[ø]	slide	[twɑ̄ɪ], [twɑ̄ɪd]
		food	[fu]
		need	[nɨ], [nɨd]
k ---> k	/	# ___	
k ---> t	/	V ___ V	
	[t]	back-i	[bæti]
		bookie	[bʊti]
		ducky	[dʌti]
		sock-i	[dɑti]
		sneaky	[nɨti]
k ---> t ~ k ~ d		/ ___ #	
	[t]	back	[bæt]
		book	[bʊt]
		duck	[dʌt]
		rock	[wɑt] (2)
		sock	[dɑt]
	[k]	cake	[kē ɪk]
		cupcake	[kʌpkē ɪk]
		fake	[fē ɪk]
		snack	[næk], [næt]
		jack	[dæk]
	[d]	look	[wʊd] (3)
		black	[fwæd]
g ---> g	/	# ___	

g ---> d / V ___ V

[d]	Ziggy	[dɪdi]

g ---> d / ___ #

[d]	pig	[pɪd]
	smug	[mʌd]
	smog	[mɑd]
	dog	[dɑd] (2)

Affricates

ʧ ---> t ~ d / # ___

[t]	cheese	[ti]
	chalk	[tɑt]
	chin	[tɪn]
	chew	[tu]
	chain	[tēɪn]
[d]	chat	[dæt] (2)
	chop	[dɑp]
	cheap	[dip]
	chick	[dɪt]

ʧ ---> t ~ ʧ / V ___ V

[t]	catching	[kætɪŋ]
	peachy	[pitɪ]
[ʧ]	watch-i	[waʧɪ]

ʧ ---> t / ___ #

[t]	catch	[kæt]
	peach	[pit]
	watch	[wɑt], [swɑt]

d ---> d ~ t / # ____

[d]	job	[dɑm]
	Jill	[dɪl]
	jar	[dɑ]
	gym	[dɪm]
	jelly	[dɛlɪ]
[t]	jump	[tʌmp], [dʌmf]
	juicy	[tutɪ]

d ---> d ~ t ~ v / V ____ V

[d]	page-i	[pēɪdɪ]
	bridge-i	[bwɪdɪ]
[t]	badge-i	[bæt͡ɪ]
[v]	cage-i	[kēɪvɪ]

d ---> d ~ t ~ Ø / ____ #

[d]	cage	[kēɪd]
	bridge	[fwɪd]
[Ø]	page	[fēɪd], [pēɪ]
[t]	badge	[bæt]

Nasals

m ---> m / # ____ ; ____ #

n ---> n / # ____ ; V ____ V ; ____ #

ŋ ---> n / V ____ V

[n]	hanger	[ænʊ]

ŋ ---> ŋ / ____ #

Liquids

l ---> w / # ____

[w]	laugh	[wæf]
	laughing	[wæfɪŋ]
	lip	[wɪp]
	like	[wāɪt]
	look	[wʊd] (3)

l ---> l ~ w / V ____ V

[l]	jelly	[dɛlə]
	vanilla	[nɪlə]
	yellow	[jɛlōʊ]
	television	[tɛləvɪdɪn]
	valentine	[væləntāɪm]
[w]	skillet	[kɪwɪt], [kɪlɪt]

l ---> l ~ ø ~ V / ____ #

[l]	nail	[nēɪl]
	cool	[kul]
	pill	[pɪl]
	pull	[ful]
	sell	[tɛl]
[ø]	fall	[fɔ]
	school	[ku], [kul] (4)
	small	[mɑ], [mɑl]
[V]	candle	[kænōʊ]

r ---> w / # ____
V ____ V

[w]	roof	[wuf]
	rose	[wo͞ʊd]
	rocky	[wɑkɨ]
	rosy	[wo͞ʊdɨ]
	right	[wa͞ɪt]
	zero	[dɨwo]
	orange	[owɪnt]
	orange-i	[owɪntɨ]

Glides

w ---> w / # ____
V ____ V

j ---> j / # ____
V ____ V

Phonetic realizations for consonant clusters

sp ---> p ~ f

[p]	speak	[pɨt]
	spend	[pɛn]
	speck	[pɛt]
	spoil	[pɔ͞ɪl]
	spider	[pa͞ɪdʊ]
[f]	speed	[fɨd]
	spit	[fɪt]
	spade	[fe͞ɪd]
	spook	[fut]

	spike	[fɑ̄ɪt]

st ---> t ~ st

[t]	sting	[tɪn]
	step	[tɛp]
	stand	[tæn]
	stew	[tu]
	start	[tɑt]
[st]	stink	[stɪnt]
	stop	[stɑv], [tɑp] (2)
	star	[stɑn], [tɑn], [tɑd]

sk ---> k ~ sk

[k]	skin	[kɪn]
	skip	[kɪp]
	scoot	[kut]
	scarf	[kɑf]
	skirt	[kʊt]
[sk]	skate	[skē͞ɪt], [kē͞ɪt] (2)

sl ---> tw

[tw]	sled	[twɛn]
	slow	[twō͞ʊ]
	slam	[twæm]
	sly	[twɑ̄ɪ]
	sleeping	[twɪpɪŋ]

sn ---> n ~ sn

[n]	sneak	[nit]
	snip	[nɪp]

	snakes	[nēɪt]
	snow	[nōʊ]
	snap	[næp]
[sn]	snake	[snēɪt], [nēɪt]

sm ---> m

[m]	smock	[mɑt]
	smart	[mɑt]
	smack	[mæt]
	smear	[mɪʊ]
	smog	[mɑd]

br ---> fw ~ bw

[fw]	brim	[fwɪm]
	bread	[fwɛn]
	brew	[fwu]
	brown	[fwāʊn]
	bright	[fwāɪt]
[bw]	brick	[bwɪt]
	bridge-i	[bwɪdi]
	bring	[bwɪŋ]
	brain	[bwēɪn]
	broke	[bwōʊt]

APPENDIX K
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 6

APPENDIX K: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 6

Subject 6

Initial phonological evaluation

Phonetic realizations for singleton consonants

Fricatives

f ---> f / # ____
V ____ V
____ #

v ---> v ~ ø / # ____

[v]	vat	[væʔ]
	vet	[vɛt]
	vine	[vāɪn]
	vote	[vō͡ʊt]
	vow	[vā͡ʊ]
[ø]	vacuum	[æʔʊm]
	valentine	[æləntāɪm]
	vanilla	[ənɪlə]

v ---> v / V ____ V
____ #

θ ---> ø / # ____

[ø]	thumb	[ʌm]

θ ---> ø / ____ #

[ø]	tooth	[tu]
	mouth	[mā͡ʊʔ]

ð ---> d ~ ø / # ____

[d]	that	[dæ]
	there	[dɛ̄ɚ], [dɛ̄ʊ]
	these	[di], [dɪʔ]
	there's	[dɛ̄ə]
	this	[dɪʔ] (5), [dɪ], [ɪʔ]
[ø]	them	[ɛm]
	they	[ēɪ]

ð ---> ʔ / V ___ V

[ʔ]	feather	[ʔɛʔə]

s ---> ø ~ ʃ ~ ʒ ~ s / # ___

[ø]	soup	[up]
	Santa	[æntə] (2)
	sun	[ʌ̃]
	same	[ēɪm]
	soapy	[ōʊ̄pi]
[ʃ]	sad	[ʃæd]
	sick	[ʃɪk]
	saw	[ʃɔ]
	say	[ʃēɪ]
	sack	[ʃæk]
[ʒ]	sock	[ʒɑk]
	sock-i	[ʒɑki]
[s]	sell	[sɛ̄ə]
	sent	[sɛn]

s ---> ʔ ~ ∅ ~ ʃ / V ___ V
___ #

[ʔ]	bus-i	[bʌʔi]
	juicy	[duʔi]
	dressy	[ʤɛʔi]
	glasses	[gæʔi]
	bus	[bʌʔ]
	juice	[duʔ]
	mouse	[māʊʔ]
	dress	[ɛʔ]
	face	[fēɪʔ]
[∅]	mousy	[māʊi]
	vase	[vēɪ], [vēɪʔ]
	this	[dɪ], [dɪʔ], [ɪʔ]
[ʃ]	icy	[āɪʃi]
	ice	[āɪʃ]

z ---> ʒ ~ ʤ ~ ∅ ~ z / # ___

[ʒ]	zero	[ʒɪwo]
	zinc	[ʒɪŋk]
	zoom	[ʒum]
	zing	[ʒɪŋ]
	zap	[ʒæp]
[ʤ]	zipping	[ʤɪpɪn]
	Ziggy	[ʤɪgi]
	zone	[ʤōʊn]
	zip	[ʤɪp]

[ø]	zipper	[ɪpə] (2)
	zebra	[ɪvwə], [zɪbwə]
	zoo	[u], [ʒu]
[z]	zany	[zēɪni]
	zebra	[ɪvwə], [zɪbwə]

z ---> ø / V ___ V

[ø]	cheesy	[tii]
	rosy	[wōʊi]
	nosy	[nōʊi]
	buzzing	[bʌɪŋ]
	music box	[muɪbɑʔ]

z ---> ø ~ ʔ / ___ #

[ø]	buzz	[bʌ]
	noise	[nɔ̄ɪ]
	Claus	[kɔ]
	rose	[wōʊ]
	nose	[nōʊ] (2)
[ʔ]	is	[ɪʔ] (2)
	does	[dʌʔ]
	these	[dɪʔ], [di]

ʃ ---> ʃ ~ ø / # ___

[ʃ]	shave	[ʃēɪv]
	shut	[ʃʌt]
	ship	[ʃɪp]
	show	[ʃ ōʊ]
	sheep	[ʃip]

	[ø]	shampoo	[æmpu]
		shovel	[ʌvə]
ʃ ---> ʔ ~ ø	/	V ___ V	
		___ #	
	[ʔ]	brushing	[ʌʔɪŋ]
		fishing	[fɪʔɪŋ]
		pushing	[pʊʔɪŋ]
		crashing	[kæʔɪŋ]
		brush	[ʌʔ]
		fish	[fɪʔ] (2)
		push	[pʊʔ]
		wash	[wɑʔ]
		toothbrush	[tuʔʌʔ]
	[ø]	washing	[wɑɪŋ]
		crash	[kæ]
ʒ ---> ʔ	/	V ___ V	
	[ʔ]	television	[tɛwəʔɪʔən]
h ---> h	/	# ___	

Stops

p ---> p	/	# ___
		V ___ V
		___ #
b ---> b	/	# ___
		V ___ V
		___ #

t ---> t / # ____
V ____ V

t ---> t ~ ʔ ~ ∅ / ____ #

[t]	cut	[kʌt]
	shirt	[ʃʌt]
	bite	[bāɪt]
	pot	[pɑt]
	shut	[ʃʌt]
[ʔ]	spit	[pɪʔ]
	vat	[væʔ]
	yet	[jɛʔ]
	right	[wāɪʔ]
	got	[gɑʔ]
[∅]	carrot	[kæɹ]
	that	[dæ]
	not	[nɑ], [nɑʔ]

d ---> d / # ____
V ____ V

d ---> d ~ ∅ / ____ #

[d]	sad	[ʃæd]
	speed	[pid]
	feed	[fid]
	food	[fud]
	made	[mēɪd]
[∅]	sled	[fɛ]
	bride	[bāɪ]

added [æ d ə]

k ---> k / # ____ ; V ____ V ; ____ # /

g ---> g / # ____ ; V ____ V ; ____ # /

Affricates

ʧ ---> ʃ ~ ʧ ~ ∅ ~ t / # ____

[ʃ]	chin	[ʃ ɪ n]
	chew	[ʃ u]
	chain	[ʃ e͞ɪ n]
	chip	[ʃ ɪ p] (2)
	chat	[ʃ æ t] (2)
[ʧ]	cheap	[ʧ i p]
	chick	[ʧ ɪ p]
[∅]	chicken	[ɪ k ə n]
	chop	[ɑ k]
[t]	cheese	[t i z]
	cheesy	[t i i]

ʧ ---> ʔ ~ ʃ / V ____ V

[ʔ]	catching	[k æ ʔ ɪ ŋ]
	peachy	[p i ʔ i]
	spatula	[p æ ʔ ə l ə]
[ʃ]	watch-i	[w ɑ ʃ i]

ʧ ---> ∅ ~ ʔ ~ ʃ / ____ #

[ø]	peach	[pi] (3), [pi?]
[ʃ]	watch	[wa], [waʃ], [wa?]
[?]	catch	[kæ?]

ʤ ---> ʤ ~ ʃ ~ d / # ___

[ʤ]	gym	[ʤɪm]
	jeep	[ʤip]
	jelly	[ʤāū]
	jack	[ʤæk]
	gee	[ʤi]
[ʃ]	jab	[ʃæb]
	jar	[ʃa]
	jerk	[ʃʊk]
	jump	[ʃʌmp], [ʤʌmp]
[d]	juice	[dʊ?]
	juicy	[dʊ?i]

ʤ ---> ? ~ ø / V ___ V
___ #

[?]	badge-i	[bæ?i]
	bridge-i	[ɪ?i]
	bridge	[ɪ?]
[ø]	page-i	[pēīi]
	page	[pēī] (2)
	cage	[kēī]
	badge	[bæ]

Nasals

m ---> m / # ___ ___ #

n ---> n / # ___ V ___ V ___ #

ŋ ---> ŋ / V ___ V

ŋ ---> ŋ ~ n / ___ #

[ŋ]	swing	[ɪŋ]
	buzzing	[bʌɪŋ]
	coughing	[kɔfɪŋ]
	eating	[ɪ̇tɪŋ]
	wing	[wɪŋ]
[n]	sting	[tɪn]
	zipping	[ʤɪpɪn]

Liquids

l ---> l / # ___ V ___ V

l ---> l ~ V ~ ∅ / ___ #

[l]	pill	[pɪl]
	all	[ɑl]
	still	[tɪl] (4)
	little	[lɪl̩]
	pineapple	[pa͡ɪnæpl̩]
[V]	school	[ku] (6)
	small	[fɑ], [ɑ]

	pull	[pu]
	cool	[ku]
[Ø]	sell	[sɛ̄ə]
	scale	[kɛ̄ə]
	Jill	[ʤɪ̄ə]
	skill	[kɪ̄ə]
	shovel	[ʌvə]

r ---> w / # ____
V ____ V

[w]	roof	[wuf]
	rose	[wō͡ʊ]
	rocky	[wɑkɪ]
	rosy	[wō͡ʊɪ]
	right	[wāɪʔ]
	hurry	[hʊwɪ]
	zero	[ʒɪwo]
	carrots	[kæwɪʔ] (2), [kæwɪ] (2)
	orange	[owɪn]
	orange-i	[owɪni]

Glides

w ---> w / # ____
V ____ V

j ---> j / # ____
V ____ V

Phonetic realizations for consonant clusters

sp ---> p ~ sp

[p]	speak	[pik]
	spade	[pēid]
	speck	[pɛk]
	spook	[puk]
	spy	[pāi]
[sp]	spot	[spat], [pat]

st ---> t

[t]	stir	[tʊ]
	sting	[tɪn]
	step	[tɛp]
	stew	[tu]
	start	[tat]

sk ---> k

[k]	skin	[kɪn]
	skip	[kɪp]
	scarf	[kōūf]
	skinny	[kɪni]
	school	[ku] (6)

sl ---> ∅ ~ f ~ s

[∅]	slow	[ōʊ]
	slap	[æp]
	sly	[āi]
	slug	[ʌg]
	sloppy	[api]
[f]	sleep	[fip], [ʧp], [ip]
	slip	[fɪp], [ʧp]

sn ---> ø ~ ʃ

[ø]	snip	[ĩp]
	snail	[ẽ̃ə̃], [ẽə]
	snake	[ẽĩk] (2)
	snakes	[ẽĩk]
	snack	[æk] (2)
[ʃ]	sneak	[ʃɪŋk]
	Snoopy	[ʃumpi]
	snow	[ʃõũ]

sm ---> ø ~ f ~ m

[ø]	smell	[ɛ̃ə] (2)
	smoke	[õũk] (2)
	smart	[ɑt]
	smile	[ãĩə] (2)
	smug	[ʌg]
[f]	smog	[fɑg]
	smack	[fæ̃]
	smear	[fĩə]
	small	[fɑ], [ɑ]
[m]	smock	[mɑk]

br ---> ø ~ f ~ b ~ fw ~ bw

[ø]	bridge	[ɪʔ]
	bring	[ɪŋ]
	brag	[æg]
	brown	[ə̃ũn]
	brush	[ʌʔ]

[f]	brim	[fɪm]
	bright	[fāɪt]
	bribe	[fāɪf]
	brat	[fæt]
	brew	[fu]
[b]	braid	[bēɪd]
	bran	[bæn]
	bride	[bāɪ]
[fw]	brick	[fwɪk]
	brad	[fwæd]
	broke	[fwōʊ]
[bw]	brain	[bwēɪn]

Follow-up phonological evaluation

Phonetic realizations for singleton consonants

Fricatives

f ---> f / # ____ ; V ____ V ; ____ #

v ---> v / # ____ ; V ____ V ; ____ #

θ ---> ∅ / # ____ ; ____ #

[∅]	thumb	[ʌm]
	think	[ɪŋk]
	tooth	[tu]

	mouth	[m$\bar{a}\upsilon$]
ð ---> d ~ ð / # ___		
[d ~ ð]	that	[dæ], [dæʔ] (2), [dæt] (3), [ðæt]
	there	[d$\bar{\varepsilon}$ð], [d$\bar{\varepsilon}$ə] (2), [d$\bar{\varepsilon}\upsilon$] (2), [ð$\bar{\varepsilon}$ð]
	this	[dɪs] (4), [dɪʔ] (2), [ðɪs]
ð ---> ʔ / V ___ V		
[ʔ]	feather	[fɛʔʊ]
s ---> ø / # ___		
[ø]	sock	[ɑk]
	soup	[up]
	sun	[ʌn]
	sick	[ɪk]
	sent	[ɛnt]
s ---> ʔ ~ ø / V ___ V		
[ʔ]	bus-i	[bʌʔi]
	mousy	[m$\bar{a}\upsilon$ʔi]
	dressy	[dʒwɛʔi]
	glasses	[glæʔəʔ]
[ø]	juicy	[dʒui]
	icy	[$\bar{a}$i]
s ---> ʔ ~ s ~ ø / ___ #		
[ʔ]	bus	[bʌʔ]

	dress	[ʤwɛʔ]
	face	[fēɪʔ]
	horse	[hɔʔ]
[s]	yes	[jɛs] (3)
	this	[dɪs] (4), [ðɪs], [dɪʔ] (2)
[ø]	ice	[āɪ]
	vase	[vēɪ], [vēɪʔ]

z ---> ø ~ ʤ ~ ʒ / # ___

[ø]	zipping	[ɪpɪŋ]
	zoom	[um]
	zinc	[ɪŋk]
	zero	[iwo]
	zoo	[u] (2)
[ʤ]	zap	[ʤæp]
	zone	[ʤōūn]
	zany	[ʤēɪni]
	zip	[ʤɪp]
[ʒ]	zebra	[ʒɪbə], [ɾbrə]
	zing	[ʒɪŋ]

z ---> ø / V ___ V

[ø]	cheesy	[tii]
	rosy	[wōūi]
	nosy	[nōūi]
	buzzing	[bʌɪŋ]
	music box	[muɪʔbak]

z ---> ø ~ z / ___ #

[ø]	cheese	[ʧiˑ]
	noise	[nɔ̄ɪ̄]
	rose	[wō ʊ̄]
	Claus	[kɔ]
	nose	[nō ʊ̄] (2)
[z]	use	[juz]
	is	[ɪz]

ʃ ---> ʃ ~ ʧ / # ___
V ___ V

[ʃ]	she	[ʃiˑ]
	shave	[ʃēɪ̄v]
	shirt	[ʃʊt]
	shape	[ʃēɪ̄p]
	sheep	[ʃip]
	brushing	[bwʌʃɪŋ]
	fishing	[fɪʃɪŋ]
	pushing	[pʊʃɪŋ]
[ʧ]	shine	[ʧāɪ̄n]
	shovel	[ʧʌvl̩]
	crashing	[kwæʧɪŋ]
	washing	[waʧɪŋ]

ʃ ---> ʃ ~ ʔ ~ ʧ / ___ #

[ʃ]	fish	[fɪʃ] (2)
	push	[pʊʃ]
	brush	[bwʌʃ]
[ʔ]	crash	[kwæʃ]

		toothbrush	[tubwʌʔ]
	[tʃ]	wash	[watʃ]
ʒ --->	ʤ	/ V ____ V	
	[ʤ]	television	[tɛləvɪʤən]
h --->	h	/ # ____	

Stops

p --->	p	/ # ____ V ____ V ____ #
b --->	b	/ # ____ V ____ V ____ #
t --->	t	/ # ____ V ____ V ____ #
d --->	d	/ # ____ V ____ V ____ #
k --->	k	/ # ____ V ____ V ____ #
g --->	g	/ # ____ V ____ V ____ #

Affricates

tʃ ---> tʃ / # ___ ; V ___ V ; ___ # /

dʒ ---> dʒ / # ___ /

dʒ ---> dʒ / V ___ V /

[dʒ]	page-i	[pēɪdʒi]
	badge-i	[bædʒi]
	bridge-i	[bwɪdʒi]
[ʒ]	cage-i	[kēɪʒi]

dʒ ---> dʒ ~ tʃ / ___ #

[dʒ]	page	[pēɪdʒ] (2)
	badge	[bædʒ]
	cage	[kēɪdʒ]
[tʃ]	bridge	[bwɪtʃ]

Nasals

m ---> m / # ___ ; ___ # /

n ---> n / # ___ ; V ___ V ; ___ # /

ŋ ---> ŋ / V ___ V ; ___ # /

Liquids

l ---> l / # ___ ; V ___ V /

l ---> l ∼ V / ____ #

[l]	cool	[kul]
	pill	[pɪl]
	fall	[fɔl]
	skill	[kɪl]
	nail	[nēɪl]
[V]	small	[ɑ̃], [ɑl]
	sell	[ɛ̄ə]
	scale	[kēɪə]
	smile	[ɑ̄ɪə], [ɑ̄ɪl]
	spoil	[pɔ̄ɪjə]

r ---> w / # ____
V ____ V

[w]	roof	[wuf]
	rose	[wōʊ̄]
	rosy	[wōʊ̄i]
	right	[wɑ̄ɪt]
	rocky	[wɑki]
	already	[ɔwɛdi]
	around	[əwɔnd]
	zero	[iwo]

Glides

w ---> w / # ____
V ____ V

j ---> j / # ____
V ____ V

Phonological realizations of consonant clusters

sp ---> p

[p]	speak	[pik]
	spend	[pɛnd]
	spook	[puk]
	spy	[pāi]
	spider	[pāidʊ]

st ---> t

[t]	sting	[tɪŋ]
	step	[tɛp]
	stew	[tu]
	store	[tɔ]
	stove	[tōʊv]

sk ---> k

[k]	skin	[kɪn]
	scooter	[kudə]
	skip	[kɪp]
	ski	[ki] (2)
	sky	[kāi] (2)

sl ---> ∅ ~ s

[∅]	slip	[ɪp] (2)
	sled	[ɛd]
	slow	[ōʊ]
	slam	[æm]
	sleigh	[ēi]
[s]	sloppy	[sapi]

sn ---> ø

[ø]	snip	[ɪp]
	snap	[æp]
	Snoopy	[upi]
	sneak	[ɪŋk]
	snub	[ʌb]

The vowels following these target clusters were often produced with nasality, e.g., snack [æ̃k] (2). However, this was inconsistent across the clusters.

sm ---> ø

[ø]	smug	[ʌg]
	smile	[ɑ̃ɪ ə], [ɑ̃ɪl]
	smell	[ɛ̃ə], [ɛl]
	small	[ɑl], [ɑ̃]
	smoke	[o̅ʊ̅k] (2)

br ---> bw ~ b

[bw]	brew	[bwu]
	bread	[bwɛd]
	brick	[bwɪk]
	bring	[bwɪŋ]
	broke	[bwo̅ʊ̅k]
[b]	brag	[bæg]

APPENDIX L
PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 7

APPENDIX L: PHONOLOGICAL RULE STATEMENTS AND EXAMPLES FOR SUBJECT 7

Subject 7

Pretraining phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> h / # ____

[h]	food	[hu]
	face	[hēɪ]
	five	[hāɪ]
	fun	[hʌn]
	fall	[hɔ]

No evidence of realization for medial /f/ was found in the sample. All examples of medial /f/ were realized as reduplications of the initial syllable. For example, the word coughing was realized as [tɔtɔ], laughing was realized as [wæwæ], and leafy was realized as [wiwi].

f ---> ʔ ~ ∅ / ____ #

[ʔ]	leaf	[wiʔ]	(2)
	roof	[wʌʔ]	
	scarf	[tɑʔ]	
	cough	[tɔʔ]	
[∅]	knife	[nɑ̄ɪ]	
	laugh	[wæ]	
	off	[jɔ]	

v ---> w ~ v ~ b / # ____

[w]	vanilla	[wɛwə]
	vat	[w æʔ]
	verb	[wʊ]
	vet	[wɛ]
	vow	[wo͞ʊ͞d]
[v]	vote	[vo͞ʊ͞ʔ]
	Vic	[vɪʔ]
	vein	[ve͞ɪŋ], [ve͞ɪm]
[b]	valentine	[b æhɪn]
	van	[b æn], [w æn]
	vase	[be͞ɪ], [we͞ɪʔ]

Examples of reduplication occurred in medial position for /v/.

	screwdriver	[dudɑ͞ɪdə]
	television	[tʌmtʌmdɪʃə]
	glove-i	[dʌdi]
	shovel	[hʌhʌ]

v ---> ø / ____ #

[ø]	shave	[he͞ɪ]
	drive	[dɑ͞ɪ]
	five	[hɑ͞ɪ]
	wave	[we͞ɪ]
	stove	[to͞ʊ͞]

θ ---> h / # ____

[h]	thumb	[hʌm]

θ ---> ø ~ ʔ / ____ #

[ø]	teeth	[tiː]
[ʔ]	mouth	[mɑ̄ɪʔ]

ð ---> d ~ ð / # ____

[d]	the	[də] (2)
	this	[dɪ] (7), [dɪ̄ə]
[ð]	that	[dæ] (3), [ðæ]

s ---> h / # ____

[h]	sock	[hɑʔ]
	soup	[huʔ]
	sun	[hʌn]
	sent	[hɛnt]
	seat	[hiːt]

Reduplication of the initial syllable was noted in examples containing the target /s/. The following examples are presented:

bus-i	[bʌbiː]
juicy	[dudiː]
dressy	[dɛdɛ]
basket	[bæbæ]
glasses	[dædæm]

s ---> ø ~ ʔ ~ ʃ / ____ #

[ø]	face	[hēɪ]
	this	[dɪ] (7), [dɪ̄ə]
	vase	[bēɪ], [wēɪʔ]
[ʔ]	bus	[bʌʔ]

	mouse	[mɑ̄ɪʔ]
	dress	[dɛʔ]
	ice	[ɑ̄ɪʔ]
[ʃ]	juice	[ʤɪʃ]
	horse	[hɔʃ]

z ---> w ~ j ~ d / # ___

[w]	zipping	[wɪwɪ]
	Ziggy	[wɪwɪ]
	zoom	[wum]
[j]	zoo	[ju], [du]
	zebra	[jɪwə] (2)
	zinc	[jɪŋk]
[d]	zone	[dōʊ̄m]
	zip	[dɪp]
	zany	[dʌŋgi]

Reduplication of the initial syllable in the realization of /z/.

[t]	rosy	[dōʊ̄ti]

z ---> ∅ / ___ #

[∅]	cheese	[ti]
	noise	[nōʊ̄]
	rose	[wōʊ̄]
	nose	[nōʊ̄]
	Claus	[tɔ]

ʃ ---> h ~ t / # ___

[h]	shave	[hēɪ]

	shovel	[hʌhʌ]
	shake	[hēɪʔ]
	sheep	[hɪʔ]
[t]	she	[ti] (2)

ʃ ---> ʔ ~ ∅ / ___ #

[ʔ]	push	[pʊʔ]
	wash	[wɑʔ]
	brush	[bʌʔ]
	fish	[hɪʔ] (2)
	toothbrush	[tɪbʌʔ]
[∅]	crash	[tæ]

ʒ ---> ʃ / V ___ V

[ʃ]	television	[tʌmtʌmdɪʃə]

h ---> h / # ___

Stops

p ---> p / # ___
V ___ V

Additional medial /p/ examples were not considered due to the process of reduplication. Examples are presented below.

soupy	[huhi]
sleeping	[hihi]
Snoopy	[nuni]
zipping	[wɪwɪ]
zipper	[wɪwɪ]

p ---> p ~ ʔ / ___ #

[p]	lip	[wɪp]
	chop	[tɑp]
	zap	[zæp]
	zip	[dɪp]
	ship	[hɪp]
[ʔ]	soup	[huʔ]
	mop	[mɑʔ]
	sheep	[hiʔ]
	shape	[hēɪʔ]
	slap	[hæʔ]

b ---> b / # ____
/ V ____ V

b ---> ∅ / ____ #

[∅]	cob	[tɑ]
	tub	[tʌ]
	verb	[wʊ]
	job	[dæ]
	job	[dɑ]

t ---> t / # ____

Examples of medial /t/ were not included in the analysis due to reduplication of the initial syllable. Examples are presented below.

bootie	[bubi]
fatty	[hæhi]
sweater	[hɛhɛ]

Further, syllable deletion was evidenced in examples containing medial /t/ in the target word. Examples are presented below.

		eating	[ɪʔ]
		Santa	[hæn]
		valentine	[bæhɪn]
		skating	[dēɪ]
t ---> ʔ ~ t ~ ø		/ ____ #	
	[ʔ]	scoot	[duʔ]
		fight	[hāɪʔ]
		vote	[vōʊʔ]
		shirt	[hɪʔ]
		bite	[bāɪʔ]
	[t]	seat	[hit]
		skirt	[dʊt]
		smart	[mɑt]
		hat	[hæt]
		sport	[pōʊt]
	[ø]	boot	[bu]
		coat	[tōʊ]
		vet	[wɛ]
		start	[tɑ]
		let	[lɛ]
d ---> d		/ # ____	

Reduplication was observed in several of the target words containing medial /d/.

		spider	[bɑ̄ɪbi]
		scooter	[dudʊ]
d ---> ∅	/ ____ #		
	[∅]	food	[hu]
		need	[ni]
		feed	[hi]
		sad	[hæ]
		made	[mēɪ]
k ---> t	/ # ____		
	[t]	cool	[tul]
		key	[ti]
		coat	[tōʊ̄]
		come	[tʌm]
		cough	[tɔʔ]

Reduplication was also observed in several of the target words containing medial /k/. Examples are presented below.

		cookie	[tʊti]
		back-i	[bæbi]
		ducky	[dʌdi]
		rocky	[wɑwi]
		sock-i	[hɑhi]
k ---> ʔ ~ k ~ ∅	/ ____ #		
	[ʔ]	spook	[puʔ]
		sick	[hɪʔ]
		sock	[hɑʔ]
		chalk	[tɔʔ]

		fake	[hēɪʔ]
	[k]	sneak	[nik]
		jerk	[ɖʊk]
		like	[wāɪk]
		black	[bæk]
		joke	[dōʊ̄k]
	[Ø]	cupcake	[tʌptēɪ] (2)
		book	[bʊ]
		spoke	[pōʊ̄]

g ---> d / # ___

[d]	gum	[dʌm]
	go	[dōʊ̄]
	got	[dɑm]
	gun	[dʌn] (2)
	get	[gɪ] (2)

g ---> Ø ~ g / ___ #

[Ø]	pig	[pɪə̄]
	slug	[hōʊ̄]
	smog	[mɑ]
	egg	[ēɪ]
[g]	brag	[bæg]
	smug	[mʌg]

Affricates

ʧ ---> t ~ ʧ / # ___

[t]	cheese	[tiː]
	chin	[tɪn]

		chop	[tɑp]
		cheap	[tiːp]
		chick	[tɪʔ]
	[ʧ]	chair	[ʧɛ͡ʊ], [tēə]
		chew	[ʧu] (4), [tu] (9)

ʧ ---> ∅ / ____ #

	[∅]	catch	[tɑ]
		peach	[piː]

ʤ ---> d ~ ʤ / # ____

	[d]	juicy	[dudiː]
		gee	[diː]
		jar	[dɑ]
		job	[dɑ]
		jab	[dæ]
	[ʤ]	juice	[ʤɪʃ]

ʤ ---> ∅ / ____ #

	[∅]	page	[pēɪ] (2)
		badge	[bæ]
		cage	[tēɪ]
		bridge	[bɪ͡ə]

Nasals

m ---> m / # ____ / ____ #

n ---> n / # ____ / V ____ V / ____ #

ŋ ---> ŋ ~ ø / ___ #

[ŋ]	wing	[wɪŋ] (2)
	bring	[bɪ̄əŋ]
	string	[tɪŋ]
[ø]	coughing	[tɔtɔ]
	fishing	[hɪhɪ]
	sleeping	[hi̇hi̇]
	driving	[dɑ̄ɪ]

Liquids

l ---> w / # ___

[w]	laugh	[wæ]
	leaf	[wi̇ʔ] (2)
	laughing	[wæwæ]
	leafy	[wi̇wi̇]
	lip	[wɪp]

Reduplication was evidenced in examples containing intervocalic /l/.

[w]	vanilla	[wɛwə]
	yellow	[wɛwɛ]

l ---> l ~ ø / ___ #

[l]	cool	[tul]
	sell	[hɛl]
	pill	[pɪl]
	nail	[nē̄ɪl]
	skill	[dɪl]
[ø]	pull	[pu]

	all	[ɑ]
	spool	[pu], [bu]
	fall	[hɔ]
	jail	[dēī]

r ---> w / # ____
V ____ V

[w]	roof	[wʌf]
	rose	[wōʊ]
	rocky	[wɑwi]
	real	[wīəl]
	rabbit	[wæbɪ]
	zero	[dɪwo]
	orange	[owɪn]

Glides

w ---> w / # ____

j ---> j / # ____
V ____ V

Cluster realizations for consonant clusters

sp ---> p ~ b

[p]	spook	[puʔ]
	spoke	[pōʊ]
	spit	[pɪʔ]
	spy	[pāī]
	speck	[pɛʔ]
[b]	spool	[bu], [pu]
	spider	[bāībɪ]

	spin	[bɛ], [pɪn], [pɪŋ]
st ---> t		
[t]	stake	[tēɪʔ]
	stew	[tu]
	stove	[tōʊ]
	start	[tɑ]
	step	[tɛp]
sk ---> d ~ k		
[d]	skin	[dɪn]
	skip	[dɪp]
	scale	[dēɪ]
	skating	[dēɪ]
	scooter	[dudʊ]
[k]	skeleton	[kɛəən]
	skinny	[kɪndi]
sl ---> h		
[h]	slow	[hōʊ]
	sleigh	[hēɪ]
	sled	[hɛʔ]
	sloppy	[hɑpi]
	sleeping	[hihi]
sn ---> n		
[n]	snow	[nōʊ]
	snap	[næʔ]
	sneak	[nik]
	sneaky	[nini]

	Snoopy	[nuni]

sm ---> m

[m]	smog	[mɑ]
	smock	[mɑʔ]
	smart	[mɑt]
	smack	[mæʔ]
	smile	[māimāi], [māil]

br ---> b ~ bw

[b]	brew	[bu]
	broke	[bōūʔ]
	brain	[bēin]
	brick	[bɪʔ]
	bright	[bāiʔ]
[bw]	bread	[bwɛ̄ə]
	bridge	[bwɪ]

Follow-up phonological evaluation

Phonetic realizations for consonant singletons

Fricatives

f ---> h ~ s:h / # ___

[h]	food	[hu]
	fight	[hāiʔ]
	fishing	[hɪhɪ]
	five	[hāi]
	feather	[hɛhɛ]
[s:h]	fat	[s:hæʔ], [hæt]
	face	[s:hēiʔ]

	fan	[s:hæn]
	phone	[s:hōūn]

Reduplication was evidenced in examples containing intervocalic /f/.

[f]	roof-i	[wʌfwʌf]
[h]	knife-i	[nāɪhi]

f ---> ʔ / ____ #

[ʔ]	knife	[nāɪʔ]
	laugh	[swæʔ]
	cough	[tɔʔ]
	leaf	[wiʔ] (2)

v ---> sw ~ w ~ b / # ____

[sw]	vote	[swōūʔ]
	Vic	[swiʔ]
	vow	[swāū]
	van	[swæn], [stæm]
[w]	vine	[wāɪn]
	vanilla	[wɛlwɪn]
	vacuum	[wæwum]
	vat	[wæʔ]
[b]	vase	[wēɪʔ], [bēɪ]
	verb	[bu]

One example of reduplication was evidenced in the word containing medial /v/.

[w]	television	[tɛlwiwɪn]

v ---> ø / ____ #

	[Ø]	shave	[hēɪ]
		five	[hāɪ]
		wave	[wēɪ]
		stove	[tōʊ]
		drive	[stāɪ]

θ ---> h / # ____

[h]	thumb	[hʌm]
	think	[hɪŋʔ]

Medial /θ/ did not occur in the environment of intervocalic singleton but instead in the environment of abutting consonants. For example, the word toothbrush was realized as [tubʌʔ]. Thus, medial /θ/ was not considered in the analysis.

θ ---> ʔ ~ Ø / ____ #

[ʔ]	teeth	[stɪʔ]
[Ø]	mouth	[māʊ]

ð ---> d / # ____

[d]	this	[dɪʔ], [dɪ] (4)
	that	[dæ] (2)
	these	[di] (6)
	they	[dēɪ]

s ---> h ~ s:h / # ____

[h]	soup	[huʔ]
	soupy	[huhu]
	saw	[hɔ]

		say	[hēɪ]
		sock	[hɑʔ]
	[s:h]	Santa	[s:hæ̈nə], [hæ̈n]
		same	[s:hēɪn]
		sick	[s:hɪʔ] [hɪʔ] (2)
s --->	ʔ ~ s	/ ___ #	
	[ʔ]	bus	[bʌʔ]
		dress	[dɛʔ]
		face	[s:hēɪʔ]
		this	[dɪʔ], [dɪ] (4)
		vase	[wēɪʔ], [bēɪ]
	[s]	juice	[ʤus]
		horse	[hɔs]
		yes	[jɛs] (4)
z --->	sw ~ d ~ st ~ h	/ # ___	
	[sw]	zoo	[swu], [du]
		zap	[swæ̈ʔ]
		zipper	[swɪwɪ], [spɪə]
	[d]	Ziggy	[dɪwi]
		zone	[dōūn]
		zebra	[diwə], [hiwəi]
	[st]	zip	[stɪp]
		zero	[stiwo]
	[h]	zing	[hɪŋ]

Three examples of reduplication in words containing medial /z/ were observed in the data and are presented below.

	noisy	[nōʊni]
	rosy	[wōʊwōʊ]
	nosy	[nōʊni]

z ---> ∅ / ____ #

[∅]	buzz	[bʌ]
	noise	[nōʊ]
	rose	[wōʊ]
	cheese	[tīʊ]
	glasses	[dæædæ]

ʃ ---> h ~ s:h ~ ʃ / # ____

[h]	shave	[hēɪ] (2)
	she	[hi]
	shape	[hēɪp]
	show	[hōʊ]
	ship	[hɪp]
[s:h]	shoe	[s:hu], [hu] (2)
	shark	[s:hɑʔ]
[ʃ]	she	[ʃi]
	shake	[ʃēɪ]

Medial /ʃ/ was not analyzed because of the process of reduplication. The examples from the data set for medial /ʃ/ are presented below.

	fishing	[hɪhɪ]
	pushing	[pʊpʊn]

ʃ ---> ʔ / ____ #

[ʔ]	push	[pʊʔ]

		brush	[bʌʔ]
		fish	[hɪʔ] (2)
		toothbrush	[tubʌʔ]

h ---> h / # ____

Stops

p ---> p ~ sp / # ____

[p]	pill	[pɪl]
	pin	[pɪn]
	pull	[pu]
	pot	[pɑʔ]
	push	[pʊʔ]
[sp]	pants	[spæn]
	pig	[spɪ]
	paint	[spēɪnt]

p ---> p / V ____ V

[p]	soapy	[hōʊphōʊp]
	apple	[æpl̩] (2)
[m]	sloppy	[hɑmi]
	sleepy	[simi]

p ---> p ~ ʔ / ____ #

[p]	step	[stɛp]
	snip	[snɪp]
	lip	[wɪp]
	ship	[hɪp]
	top	[tɑp]
[ʔ]	soup	[huʔ]

		zap	[swæʔ]
		sheep	[hiʔ]
		mop	[mɑʔ]
b ---> b ~ sb		/ # ___	
	[b]	book	[bʊ]
		boot	[bu]
		bus	[bʌʔ]
		buzz	[bʌ]
		badge	[bæ]
	[sb]	boats	[sbo͞ʊ]
b ---> ∅ ~ b		/ ___ #	
	[∅]	verb	[bʊ]
		bribe	[bɑ͞i]
		job	[dɑ]
		snub	[smʌ]
	[b]	stab	[stæb]
		jab	[stɑb]
		cob	[stɑb]
t ---> t		/ # ___	
	[t]	tail	[te͞il]
		top	[tɑp]
		tub	[tʌn]
		tea	[ti]
		take	[te͞i]

In addition to the reduplication present in examples containing intervocalic /t/, a context-specific rule was

evidenced in Eric's realization. The rule involved /t/ produced as [t] only in the enviroment of [n ____ V]. Examples are presented below.

	[t]	pretend	[ənt ɪn]
		skeleton	[dɛl ɪntɪn]
		valentine	[dæləntāɪn]
t ---> ʔ ~ ∅ ~ t ~ p		/ ____ #	
	[ʔ]	pot	[pɑʔ]
		coat	[tōūʔ]
		shirt	[hʌʔ]
		scoot	[tuʔ]
		state	[stēɪʔ]
	[∅]	boot	[bu]
		bite	[bāɪ], [bāɪʔ]
		spit	[spɪ]
		sport	[spɔ]
		let	[wɑ]
	[t]	eat	[it]
		forgot	[ədɑt]
		bright	[spāɪt]
		skirt	[stʊt]
		Scott	[stɑt]
d ---> d		/ # ____	
d ---> ∅		/ ____ #	
	[∅]	food	[hu]
		lid	[wɪ]

		dad	[dæ]
		bread	[bɛ̄o]
		lemonade	[wɛnēɪ]

k ---> t ~ st / # ___

[t]	cool	[tu]
	cup	[tʌp]
	coat	[tōʊʔ]
	cough	[tɔʔ]
	cage	[tēɪ]
[st]	cut	[stʌt]
	cutting	[stʌnʌn]
	cob	[stɑb]
	kite	[stāɪt]
	candle	[stænōʊ]

k ---> ʔ ~ ∅ ~ k / ___ #

[ʔ]	sock	[hɑʔ]
	chick	[tɪʔ]
	stake	[tēɪʔ]
	sack	[hæʔ]
	duck	[dʌʔ]
[∅]	take	[tēɪ]
	make	[mēɪ]
	book	[bʊ]
	sneak	[sni]
	spook	[pu]
[k]	cake	[tēɪk]

	stack	[tæk], [stæʔ]
	stick	[stɪk], [tɪ̄ə̄]
	smack	[smæk]
	snack	[næk], [snæʔ]

g ---> ∅ / ____ #

[∅]	pig	[spɪ]
	brag	[bæ]
	smug	[mʌ]
	smog	[smɑ]
	egg	[ēɪ] (3)

Affricates

ʧ ---> t / # ____

[t]	chew	[tu]
	chain	[tēɪn]
	cheap	[tip]
	chop	[tɑp]
	cheese	[tɪ̄ū]

ʧ ---> ʔ / ____ #

[ʔ]	catch	[tɛʔ]
	peach	[pɪʔ]
	watch	[swæ], [waʔ]

ʧ ---> st ~ d ~ ʤ / # ____

[st]	jeep	[stip]
	gym	[stɪm]
	jab	[stɑb]
	jerk	[stʊʔ]

		joke	[stōʊʔ]
	[d]	jar	[dɑ]
		job	[dɑ]
		jelly	[dɛdi]
		jump	[dʌmp], [stʌmp]
	[ʤ]	juice	[ʤus]
		juicy	[ʤusʤus]

ʤ ---> ∅ / ____ #

	[∅]	cage	[tēɪ]
		bridge	[bɪʊ]
		badge	[bæ]
		page	[pēɪ] (2)

Nasals

m ---> m / # ____ ; V ____ V ; ____ #

n ---> n / # ____ ; V ____ V ; ____ #

ŋ ---> ŋ / V ____ V

ŋ ---> ∅ ~ n ~ ŋ / ____ #

	[∅]	skating	[tēɪwə]
		waving	[wēɪwə]
		washing	[swɑwi]
		sleeping	[simi]
		shaving	[hēɪhi]

[n]	bring	[spɹ̄ə̄n]
	zipping	[jɪwɪn]
	pushing	[pʊpʊn]
	cutting	[stʌnʌn]
	catching	[tɛtɛn]
[ŋ]	eating	[siʔɪŋ]
	wing	[wɪŋ]
	sting	[stɪŋ]
	string	[tɪŋ]

Liquids

l ---> w / # ___

[w]	laughing	[wæwæ]
	leafy	[wiwi]
	little	[wɪwu]
	lid	[wɪ]
	let	[wɑ]

l ---> l ~ w / V ___ V

[l]	valentine	[dæləntāɪn]
	skeleton	[dɛlɪntɪn]
	television	[tɛlwɪwɪn]
	skillet	[stilɪn], [stɹ̄ə̄wə]
[w]	yellow	[wɛwɛ]

l ---> l ~ ϕ / ___ #

[l]	pill	[pɪl]
	tail	[tē̄ɪl]
	nail	[nē̄ɪl]

	sell	[hɛ̄əl]
	skill	[stɪl]
[Ø]	cool	[tu]
	pull	[pu]
	fall	[hɔ]
	all	[ɑ]
	jail	[tē ɪ]

r ---> w / # ____

[w]	roof	[wuf]
	rose	[wōū]
	rocky	[wɑwi]
	rosy	[wōūwōū]
	rock	[wɑʔ] (2)

Glides

w ---> w ~ sw / # ____

[w]	wash	[wɑʃ]
	wave	[wē ɪ]
	wing	[wɪŋ]
	waving	[wē ɪwi]
	watch-i	[wɑwi]
[sw]	watch	[swɑʔ], [wɑʔ]
	washing	[swɑwi]

j ---> j / # ____
/ V ____ V

Phonological realizations for consonant clusters

sp ---> sp ~ p

[sp]	speed	[spid]
	spade	[spēɪ]
	spike	[spāɪ]
	spend	[spɛn]
	spy	[spāɪ]
[p]	spook	[pu]
	spider	[pāɪbi]
	spill	[pɪl], [spɪl] (2)
	spin	[pɪn] (2)

st ---> st ~ t

[st]	step	[stɛp]
	sting	[stɪŋ]
	state	[stēɪʔ]
	stand	[stæn]
	stone	[stōʊn]
[t]	stew	[tu]
	stair	[tɛ̄ō]
	stake	[tēɪʔ]
	stamp	[tæmp]
	stove	[tōʊ]

sk ---> st ~ t ~ d

[st]	scooter	[stu]
	scat	[stæʔ]
	scale	[stēɪ]
	skip	[stɪp]
	skinny	[stɪni]

[t]	skin	[tɪn]
	skating	[tēɪwɪ]
	scoot	[tu:]
	school	[tu] (3), [stu]
	scarf	[tɑ]
[d]	skeleton	[dɛlɪntɪn]
	sky	[dāɪ], [stāɪ]
	skate	[dēɪt], [stēɪt]

sl ---> h ~ s:h ~ s

[h]	slam	[hæm]
	slow	[hōʊ]
	slip	[hɪp] (2)
	sly	[hāɪ]
	sloppy	[hɑmi]
[s:h]	sleigh	[s:hēɪ]
	slug	[s:hʌ]
	sled	[s:hɛ̄ə]
	slide	[s:hāɪ], [hāɪ]
[s]	sleeping	[simi]
	sleep	[sip], [hip] (2)

sn ---> sn ~ n

[sn]	snip	[snɪp]
	snow	[snōʊ]
	sneak	[sni]
	snail	[snēɪl] (2)
	snap	[snæp]

[n]	Snoopy	[nuni]
	snakes	[nēɪʔ]
	sneaky	[nini]
	snake	[nēɪʔ], [snēɪ]
	snack	[næk], [snæʔ]

sm ---> sm ~ m

[sm]	smear	[smɪʊ̄]
	smack	[smæk]
	smack	[smæ]
	smart	[smɑʔ]
	smell	[smɛl], [mɛl]
[m]	smug	[mʌ]
	smoke	[mōʊ̄ʔ], [smōʊ̄]
	small	[mɑ], [smɑ]
	smile	[māɪmi], [smāɪjə]

br ---> sp ~ b

[sp]	brick	[spɪʔ]
	brew	[spun]
	bride	[spāɪ]
	bright	[spāɪt]
	brushing	[spʌnə]
[b]	bread	[bɛ̄ō]
	brag	[bæ]
	brown	[bāʊ̄n]
	bribe	[bāɪ]
	brush	[bʌʔ]

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BIOGRAPHICAL SKETCH

Lori Lee Stewart Gonzalez was born in Mt. Vernon, Kentucky, a small community at the foothills of the Appalachian Mountains on October 20, 1957. She lived in Mt. Vernon with her parents, Wayne and Ruby, her two sisters, Ann and Serena, and her brother, Bill. She attended elementary and high school in Mt. Vernon.

Lori attended the University of Kentucky in Lexington, where she received a Bachelor of Arts degree in education with emphasis in speech pathology and audiology in May of 1975. She received a Master of Arts degree in communication disorders at the Eastern Kentucky University (EKU) in Richmond, Kentucky. It was at EKU that she met Alice T. Dyson, Ph.D., her supervising professor at the University of Florida.

In 1985, Lori moved to Gainesville, Florida, to attend the University of Florida to obtain the Doctor of Philosophy degree in speech. Her dissertation was directed by Dr. Alice Dyson. Lori's expected date of graduation is May 1989.

In April, 1988, Lori married Randall John Gonzalez. In August, 1988, Lori accepted a position as Assistant Professor at Southern Illinois University at Carbondale. She and Randy now reside in Carbondale, Illinois.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Alice Tanner Dyson, Chair
Assistant Professor of Speech

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Linda J. Lombardino
Associate Professor of Speech

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Patricia B. Kricos
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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Professor of Special Education

This dissertation was submitted to the Graduate Faculty of the Department of Speech in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfullment of the requirements for the degree of Doctor of Philosophy.

May 1989

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